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DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS

RST-15653R (March 2002)

Superseding
15653R (August 2000)
CEGS-15653 (September 1993)
CEGS-15653 (July 1989)

GUIDE SPECIFICATION FOR CONSTRUCTION

Specification revised to meet U.S. Army Reserve requirements (March 2002)
Includes Special Change (Submittal Paragraph)(June 2000)
Includes changes through Notice 11 (March 2000)
Includes Special Change (Tailoring Options) (April 1998)
Includes Text Adjustment Change (Section Reference)(June 1997)

Latest change indicated by CHG tags

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SECTION 15653R

AIR-CONDITIONING SYSTEM (UNITARY TYPE)
03/02

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NOTE: This guide specification covers the requirements for single- and multi-zone air-conditioners, water-to-air and air-to-air heat pumps, condenser, humidifiers and cooling towers. This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-1-8155.

Comments and suggestions on this guide specification are welcome and should be directed to the proponent of the specification. A listing of proponents, including their organization designation and telephone number, is at URL http://www.hnd.usace.army.mil/techinfo/index.htm, and an electronic feedback page for submission of recommended changes is available at the same address. Use of electronic communication is encouraged.

NOTE: RST-15653 is a Louisville District Army Reserve Support Team (RST) version of CEGS-15653. Any text changed by the RST is underlined. Refer all specification comments to the RST

This guide specification includes tailoring options

for room unit, package systems, split system, and AC for EDP. Selection or deselection of a tailoring option will include or exclude that option in the section, but editing the resulting section to fit the project is still required.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 210/240	(1994) Unitary Air-Conditioning and Air-Source Heat Pump Equipment
ARI 270	(1995) Sound Rating of Outdoor Unitary Equipment
ARI 310/380	(1993) Packaged Terminal Air-Conditioners and Heat Pumps
ARI 320	(1998) Water-Source Heat Pumps
ARI 325	(1998) Ground Water-Source Heat Pumps
ARI 340/360	(1993) Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
ARI 350	(1986) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment
ARI 370	(1986) Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
ARI 410	(1991) Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 460	(1994) Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ARI 490	(1998) Remote Mechanical-Draft Evaporative

	Refrigerant Condensers
ARI 495	(1999) Refrigerant Liquid Receivers
ARI 500	(1990) Variable Capacity Positive Displacement Refrigerant Compressors and Compressor Units for Air-Conditioning and Heat Pump Applications
ARI 700	(1995; Apx C) Specifications for Fluorocarbon and Other Refrigerants
ARI 710	(1995) Liquid-Line Driers
ARI 720	(1997) Refrigerant Access Valves and Hose Connectors
ARI 750	(1994) Thermostatic Refrigerant Expansion Valves
ARI 760	(1994) Solenoid Valves for Use with Volatile Refrigerants

AIR DIFFUSION COUNCIL (ADC)

ADC 1062:GRD	(1984) Test Codes for Grilles, Registers and Diffusers

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 500	(1994) Test Methods for Louvers, Dampers and Shutters

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S1.13	(1995) Methods for the Measurement of Sound Pressure Levels

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 47	(1999) Ferritic Malleable Iron Castings
ASTM A 47M	(1999) Ferritic Malleable Iron Castings (Metric)
ASTM A 48	(1994a) Gray Iron Castings
ASTM A 48M	(1994el) Gray Iron Castings (Metric)
ASTM A 53	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 106	(1999el) Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A 123/A 123M	(1997ael) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(1998) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 181/A 181M	(1995b) Carbon Steel Forgings, for General-Purpose Piping
ASTM A 183	(1983; R 1998) Carbon Steel Track Bolts and Nuts
ASTM A 193/A 193M	(1999) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 234/A 234M	(1999) Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 307	(1997) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 334/A 334M	(1999) Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service
ASTM A 536	(1999el) Ductile Iron Castings
ASTM A 653/A 653M	(1999) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 733	(1999) Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B 32	(1996) Solder Metal
ASTM B 62	(1993) Composition Bronze or Ounce Metal Castings
ASTM B 75	(1997) Seamless Copper Tube
ASTM B 75M	(1997) Seamless Copper Tube (Metric)
ASTM B 88	(1996) Seamless Copper Water Tube
ASTM B 88M	(1996) Seamless Copper Water Tube (Metric)
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM B 280	(1998) Seamless Copper Tube for Air Conditioning and Refrigeration Field

	Service
ASTM B 650	(1995) Electrodeposited Engineering Chromium Coatings of Ferrous Substrates
ASTM B 813	(1993) Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
ASTM C 67	(1998a) Sampling and Testing Brick and Structural Clay Tile
ASTM C 534	(1999) Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C 916	(1985; R 1996el) Adhesives for Duct Thermal Insulation
ASTM C 1071	(1998) Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material)
ASTM D 520	(1984; R 1995el) Zinc Dust Pigment
ASTM D 596	(1991; R 1995) Reporting Results of Analysis of Water
ASTM D 1384	(1997a) Corrosion Test for Engine Coolants in Glassware
ASTM D 1784	(1999a) Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D 2000	(1999) Rubber Products in Automotive Applications
ASTM D 3308	(1997) PTFE Resin Skived Tape
ASTM E 84	(1999) Surface Burning Characteristics of Building Materials
ASTM E 437	(1997) Industrial Wire Cloth and Screens (Square Opening Series)
ASTM F 104	(1995) Nonmetallic Gasket Materials
ASTM F 872	(1984; R 1990) Filter Units, Air Conditioning: Viscous-Impingement Type, Cleanable

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(1994) Safety Code for Mechanical Refrigeration
ASHRAE 34	(1997) Number Designation and Safety Classification of Refrigerants
ASHRAE 52.1	(1992) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
ASHRAE 64	(1995) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers
ASHRAE 127	(1988) Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 1992) Pipe Threads, General Purpose (Inch)
ASME B16.5	(1996; B16.5a) Pipe Flanges and Flanged Fittings NPS 1/2 thru NPS 24
ASME B16.9	(1993) Factory-Made Wrought Steel Buttwelding Fittings
ASME B16.11	(1996) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(1995; B16.22a1998) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
ASME B31.1	(1998) Power Piping
ASME B31.5	(1992; B31.5a1994) Refrigeration Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPV VIII Div 1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1

- Basic Coverage

ASME BPV IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME PTC 23	(1986; Addenda 1992, R 1997) Atmospheric Water Cooling Equipment

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(1997) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS Brazing Hdbk	(1991) Brazing Handbook
AWS A5.8	(1992) Filler Metals for Brazing and Braze Welding
AWS D1.1	(1998) Structural Welding Code - Steel

ASSOCIATION OF HOME APPLIANCE MANUFACTURERS (AHAM)

AHAM Directory	(1997) Directory of Certified Room Air Conditioners

CALIFORNIA REDWOOD ASSOCIATION (CRA)

CRA RIS-01-SS	(1997) Standard Specifications for Grades of California Redwood Lumber

COOLING TOWER INSTITUTE (CTI)

CTI ATC-105	(1997) Acceptance Test Code
CTI Std-103	(1994) The Design of Cooling Towers with Redwood Lumber
CTI Std-111	(1998) Gear Speed Reducers
CTI Std-112	(1986) Pressure Preservative Treatment of Lumber
CTI Std-114	(1996) The Design of Cooling Towers with Douglas Fir Lumber
CTI Std-134	(1996) Plywood for Use in Cooling Towers
CTI Std-137	(1994) Fiberglass Pultruded Structural Products for Use in Cooling Towers

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds (1998; 7th Edition) EJMA Standards

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.5 (1994) Centrifugal Pumps

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25 (1998) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-58 (1993) Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-67 (1995) Butterfly Valves

MSS SP-69 (1996) Pipe Hangers and Supports - Selection and Application

MSS SP-70 (1998) Cast Iron Gate Valves, Flanged and Threaded Ends

MSS SP-71 (1997) Cast Iron Swing Check Valves, Flanges and Threaded Ends

MSS SP-72 (1992) Ball Valves with Flanged or Butt-Welding Ends for General Service

MSS SP-78 (1998) Cast Iron Plug Valves, Flanged and Threaded Ends

MSS SP-80 (1997) Bronze Gate, Globe, Angle and Check Valves

MSS SP-85 (1994) Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

MSS SP-110 (1996) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (1997) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA ICS 6 (1993) Industrial Control and Systems, Enclosures

NEMA MG 1 (1998) Motors and Generators

NEMA MG 2 (1989) Safety Standard for Construction and Guide for Selection, Installation, and

	Use of Electric Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(1996; Errata) National Fuel Gas Code
NFPA 70	(1999) National Electrical Code
NFPA 90A	(1996) Installation of Air Conditioning and Ventilating Systems
NFPA 214	(1996) Water-Cooling Towers
NFPA 255	(1996) Method of Test of Surface Burning Characteristics of Building Materials

NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)

NAIMA AH115	(1993) Fibrous Glass Duct Construction Standards

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA Install Fire Damp HVAC	(1992) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
SMACNA TAB HVAC Sys	(1993) HVAC Systems - Testing, Adjusting and Balancing
SMACNA Leakage Test Mnl	(1985) HVAC Air Duct Leakage Test Manual

UNDERWRITERS LABORATORIES (UL)

UL 181	(1996; Rev Dec 1998) Factory-Made Air Ducts and Air Connectors
UL 207	(1993; Rev thru Oct 1997) Refrigerant-Containing Components and Accessories, Nonelectrical
UL 214	(1997) Tests for Flame-Propagation of Fabrics and Films
UL 484	(1993; Rev thru Feb 1999) Room Air Conditioners
UL 555	(1999) Fire Dampers
UL 586	(1996; Rev thru Aug 99) High-Efficiency, Particulate, Air Filter Units
UL 723	(1996; Rev thru Dec 1998) Test for Surface Burning Characteristics of Building

	Materials
UL 900	(1994; Rev thru Apr 1997) Test Performance of Air Filter Units
UL 1995	(1995; Rev thru Jul 98) Heating and Cooling Equipment
UL Bld Mat Dir	(1999) Building Materials Directory
UL Elec Const Dir	(1998) Electrical Construction Equipment Directory
UL Fire Resist Dir	(1999) Fire Resistance Directory (2 Vol.)

WESTERN WOOD PRODUCTS ASSOCIATION (WWPA)

WWPA Grading Rules	(1999) Western Lumber Grading Rules 95

1.2 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

Indicate submittal classification in the blank space following the name of the item requiring the submittal by using "G" when the submittal requires Government approval. Submittals not classified as "G" will show on the submittal register as "Information Only". For submittals requiring Government approval, a code of up to three characters should be used following the "G" designation to indicate the approving authority; codes of "RE" for Resident Engineer approval, "ED" for Engineering approval, and "AE" for Architect-Engineer approval are recommended.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Air-Conditioning/Heat Pump System; [_____].

Drawings shall provide adequate detail to demonstrate compliance

with contract requirements. Drawings shall consist of:

(1) Equipment layouts which identify assembly and installation details.

(2) Piping layouts which identify valves and fittings.

(3) Plans and elevations which identify clearances required for maintenance and operation.

(4) Wiring diagrams which identify each component individually and interconnected or interlocked relationships between components.

(5) Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for equipment indicated or required to have concrete foundations.

(6) Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

(7) Automatic temperature control diagrams and control sequences.

(8) Installation details which includes the amount of factory set superheat and corresponding refrigerant pressure/temperature.

****

NOTE: Vendor information that forms part of this guide specification is permissible to use as long as the salient features provide for "or equal" product equivalents are specified. Submittal clauses must be modified to make known that specific vendor information is being specified. If the Contractor chooses to provide the specified vendor's product, the submittal for that item is considered a For Information Only. If the Contractor uses a different "or equal" item, then it will be evaluated against the salient features. Hence, it is considered for Government Approval (G). The Resident Engineer (RE) will typically perform the approval.

****

Manufacturers products listed below are referenced to establish a standard of quality. When the specific product listed is submitted by the Contractor, that submittal will be considered For Information Only. When an equal to that named in this specification is submitted, it shall be for Government Approval (G). The following manufacturer products are specifically mentioned in this specification:

[UNITARY EQUIPMENT, SPLIT SYSTEM UNIT] [CONDENSING OR CONDENSER UNIT]Carrier Corp., Model [_____]; FIO
[UNITARY EQUIPMENT, SPLIT SYSTEM UNIT] [CONDENSING OR CONDENSER

UNIT]Dunham-Bush, Inc., Model [_____]; FIO
[UNITARY EQUIPMENT, SPLIT SYSTEM UNIT] [CONDENSING OR CONDENSER UNIT]Snyder General Corp., Model [_____]; FIO
[UNITARY EQUIPMENT, SPLIT SYSTEM UNIT] [CONDENSING OR CONDENSER UNIT]Trane Company., Model [_____]; FIO
[UNITARY EQUIPMENT, SPLIT SYSTEM UNIT] [CONDENSING OR CONDENSER UNIT]York International Corp., Model [_____]; FIO
[UNITARY EQUIPMENT, SPLIT SYSTEM UNIT] [CONDENSING OR CONDENSER UNIT]Manuf. Prod. submitted as an "or equal"; G RE.
FORCED AIR FURNACE UNIT Snyder General Corp., Model [_____]; FIO
FORCED AIR FURNACE UNIT Trane Company, Model [_____]; FIO
FORCED AIR FURNACE UNIT York International Corp., Model [_____]; FIO
FORCED AIR FURNACE UNIT Manuf. Prod. submitted as an approved equal ; G RE
COOLING TOWER, Baltimore Aircoil Co., Model [_____]; FIO.
COOLING TOWER, Evapco, Inc., Model [_____]; FIO
COOLING TOWER, Marley Cooling Tower Co., Model [_____]; FIO
COOLING TOWER, Manuf. Prod. submitted as an "or equal"; G RE.
DIAPHRAGM-TYPE EXPANSION TANKS, Armstrong Pumps, Inc., Model [_____]; FIO
DIAPHRAGM-TYPE EXPANSION TANKS, Bell & Gossett Corp., Model [_____] ; FIO
DIAPHRAGM-TYPE EXPANSION TANKS, Taco, Inc., Model [_____]; FIO
DIAPHRAGM-TYPE EXPANSION TANKS, Manuf. Prod. submitted as an "or equal"; G RE.

SD-03 Product Data

Air-Conditioning/Heat Pump System; [_____].

Manufacturer's standard catalog data, prior to the purchase or installation of a particular component, shall be highlighted to show brand name, model number, size, options, performance charts and curves, etc. in sufficient detail to demonstrate compliance with contract requirements. Data shall be submitted for each specified component. Data shall include manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Water Treatment Systems; [_____].

[Six] [_____] complete copies of the proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions, a list of the types and proportions of chemicals used, the final treated water conditions, and a description of all environmental concerns for handling the chemicals.

Spare Parts Data; [_____].

Spare parts data for each different item of equipment specified,

after approval of detail drawings and not later than [_____] months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

SD-05 Design Data

Qualifications; [_____]

A letter listing the qualifying procedures for each welder. The letter shall include supporting data such as test procedures used, what was tested etc., and a list of the names of qualified welders and their identification symbols.

Verification of Dimensions; FI0

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

SD-06 Test Reports

Tests; FIO

A letter, at least [10] [_____] working days in advance of each tests, advising the Contracting Officer of the test. Individual letters shall be submitted for the condenser water system, refrigerant system, ductwork leak tests, cooling tower tests, condenser water quality tests, and the system performance tests. Each letter shall identify the date, time, and location for each test.

Demonstrations; G.

A letter, at least 14 working days prior to the date of the proposed training course, which identifies the date, time, and location for the training.

SD-07 Certificates

Air-Conditioning/Heat Pump System; [_____].

Where the system, components, or equipment are specified to comply with requirements of ARI, ASHRAE, ASME, or UL, proof of such compliance shall be provided. The label or listing of the specified agency shall be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating

conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

Service Organizations; [_____].

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

SD08 Manufacturer's Instructions

Framed Instructions; FIO

Framed instructions for posting, at least 2 weeks prior to construction completion.

SD-09 Manufacturer's Field Reports

Tests; G.

[Six] [_____] copies of each test containing the information described below in bound 216 x 279 mm (8-1/2 x 11 inch) 8-1/2 x 11 inch booklets. Individual reports shall be submitted for the condenser water system, refrigerant system, ductwork leak tests, and the cooling tower tests.

(1) The date the tests were performed.

(2) A list of equipment used, with calibration certifications.

(3) Initial test summaries.

(4) Repairs/adjustments performed.

(5) Final test results.

Condenser Water Quality Tests; [_____].

Test reports, each month for a period of one year after project completion, in bound 216 x 279 mm (8-1/2 x 11 inch) 8-1/2 x 11 inch booklets. The reports shall identify the chemical composition of the condenser water. The reports shall also include a comparison of the manufacturer's recommended operating conditions for the cooling tower and condenser in relation to the condition of the condenser water. Any required corrective action shall be documented within the report.

System Performance Tests; G.

[Six] [_____] copies of the report shall be provided in bound 216 x 279 mm (8-1/2 x 11 inch) 8-1/2 x 11 inch booklets. The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C 5 degrees F apart:

(1) Date and outside weather conditions.

(2) The load on the system based on the following:

(a) The refrigerant used in the system.
(b) Condensing temperature and pressure.
(c) Suction temperature and pressure.
(d) Ambient, condensing and coolant temperatures
(e) Running current, voltage and proper phase sequence for each phase of all motors.

(3) The actual on-site setting of operating and safety controls.

(4) Thermostatic expansion valve superheat - value as determined by field test

(5) Subcooling

(6) High and low refrigerant temperature switch set-points

(7) Low oil pressure switch set-point

(8) Defrost system timer and thermostat set-points

(9) Moisture content

(10) Capacity control set-points

(11) Field data and adjustments which affect unit performance and energy consumption.

(12) Field adjustments and settings which were not permanently marked as an integral part of a device.

Inspections; [_____].

Test report, at the completion of one year of service, in bound 216 x 279 mm (8-1/2 x 11 inch) 8-1/2 x 11 inch booklets. The report shall identify the condition of the cooling tower and condenser. The report shall also include a comparison of the condition of the cooling tower and condenser with the

manufacturer's recommended operating conditions.

SD-10 Operation and Maintenance Data

Operation Manual; [_____].

[Six] [_____] complete copies of an operation manual in bound 216 x 279 mm (8-1/2 x 11 inch) 8-1/2 x 11 inch booklets listing step-by-step procedures required for system startup, operation, and shutdown. The booklets shall include the manufacturer's name, model number, and parts list. The manuals shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.

Maintenance Manual; [_____].

[Six] [_____] complete copies of maintenance manual in bound 216 x 279 mm (8-1/2 x 11 inch) 8-1/2 x 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

Water Treatment Systems; [_____].

[Six] [_____] complete copies of operating and maintenance manuals for the step-by-step water treatment procedures. The manuals shall include testing procedures used in determining water quality.

1.3 QUALIFICATIONS

****
NOTE: If the need exists for more stringent requirements for weldments, delete the first bracketed statement, otherwise delete the second.
****

[Piping shall be welded in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPV IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record.] [Welding and nondestructive testing procedures shall be as specified in Section 05093 WELDING PRESSURE PIPING.] Structural members shall be welded in accordance with Section 05055 WELDING, STRUCTURAL.

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather and contamination. Proper protection and care of all material before, during, and after installation

shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. Equipment, ductwork, and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

PART 2 PRODUCTS

****

NOTE: Inapplicable equipment and system requirements will be deleted or modified in all paragraphs to suit the system designed. Coordinate the standard and design option features typical for each Air-Conditioning/Heat Pump unit and individual installation. Care must be taken to avoid specifying design options which are generally unavailable in certain combinations or are inappropriate for the application.

Projects which include vapor-compression type refrigeration systems will comply with the safety standards defined in ASHRAE 15. Designers will be responsible for thoroughly researching and implementing the ASHRAE 15 safety requirements. For refrigerant-containing parts (excluding piping) located within an indoor space, a designer can use the following 6-step synopsis as a guide in determining "System Application Requirements" from ASHRAE 15.

Step 1. Identify the safety group classification of the refrigerant anticipated to be used in the new refrigeration equipment. Refrigerants R-22 and R-134a are considered Group A1 refrigerants. Refrigerant R-123 is considered a

Group B1 Refrigerant.

Step 2. Identify the occupancy classification of the facility which will house the new refrigerant equipment. Occupancies include institutional, public assembly, residential, commercial, large mercantile, industrial, and mixed types.

Step 3. Determine the system probability (high or low) of the new refrigeration equipment. Split system applications are typically considered high-probability systems according to ASHRAE 15.

Step 4. Estimate the quantity of refrigerant (grams or pounds) in the largest single refrigerant circuit of the new equipment. The designer will research catalog data from different manufacturers in order to get an approximation.

Step 5. Determine the volume (cubic meters or cubic feet) of the indoor space which is planned to house the new refrigeration equipment.

Step 6. Identify the "System Application Requirements" from the applicable table in ASHRAE 15 based upon the information identified in the previous steps (e.g., safety group, occupancy, system probability, refrigerant quantity, and indoor space volume). The "System Application Requirements" will dictate applicable refrigerant limitations as well as occupied space or mechanical room requirements.

ASHRAE 15 refers to a mechanical room as a machinery room, however the terms are synonymous. On mechanical room design, ASHRAE 15 touches on criteria concerning equipment placement, ventilation design, door and passageway restrictions, refrigerant monitoring, open-flame devices, pressure-relief and purge piping. In addition to mechanical room design, ASHRAE 15 also touches on criteria concerning refrigerant piping, signs, self-contained breathing apparatus (SCBA), and miscellaneous installation restrictions. (SCBAs cannot be considered MCA funded items and are therefore not included in this specification.)

****

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid

opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

****

NOTE: In a salt water environment substitute acceptable non-corroding metal such as but not limited to nickel-copper, 304 stainless steel, or monel. Aluminum is unacceptable. Nomenclature (or system identification) should be established by the designer.

****

Major equipment including compressors, condensers, receivers, heat exchanges, fans, cooling towers, pumps and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of [anodized aluminum] [stainless steel] [_____]. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

****

NOTE: Where motor starters for mechanical equipment are provided in motor-control centers, the references to motor starters will be deleted.

****

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics shall be as shown, and unless otherwise indicated, all motors of 746 kW (1 hp) 1 horsepower and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered

interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided.

2.4 MISCELLANEOUS MATERIALS

2.4.1 Gaskets

Gaskets shall conform to ASTM F 104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 370 degrees C (700 degrees F) 700 degrees F service.

2.4.2 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A 307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A 307.

2.4.3 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

2.4.4 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.4.5 Pressure and Vacuum Gauge

Gauge shall conform to ASME B40.1, Class 1, 2, or 3, Style X, Type I or III as required, 115 mm (4-1/2 inches) 4-1/2 inches in diameter with phenolic or metal case. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.4.6 Temperature Gauges

Industrial duty thermometers shall be provided for the required temperature range. Thermometers shall have Celsius scale in 1 degree Fahrenheit scale in 2 degree graduations scale on a white face. The pointer shall be adjustable.

2.4.6.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 229 mm (9 inches) 9 inches long, with clear acrylic lens, and non-mercury filled glass tube.

2.4.6.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 89 mm (3-1/2 inches), 3-1/2 inches, stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

2.4.6.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 89 mm (3-1/2 inches), 3-1/2 inches, stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.4.6.4 Thermal Well

Thermal well shall be identical size, 15 or 20 mm (1/2 or 3/4 inch) 1/2 or 3/4 inch NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 15 mm (1/2 inch) 1/2 inch NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 25 mm.1 inch.

2.4.7 Unicellular Plastic Foam

Unicellular plastic foam shall be in accordance with ASTM C 534, Form T, except that D-Factor shall not exceed 0.28 at 24 degrees C (75 degrees F) 75 degrees F mean temperature.

2.4.8 Bird Screen

Screen shall be in accordance with ASTM E 437, Type 1, Class 1, 2 by 2 mesh, 1.6 mm (0.063 inch) 0.063 inch diameter aluminum wire or 0.79 mm (0.031 inch) 0.031 inch diameter stainless steel wire.

2.5 UNITARY EQUIPMENT, ROOM UNIT

2.5.1 Window or Through-the-Wall Mounted Unit

****

NOTE: Indicate unit capacity, voltage, phase, installation requirements, etc. on the drawings. At a minimum, efficiencies for these units will be in accordance with paragraph "Equipment Efficiency".

****

Unit shall be a [window] [through-the-wall] mounted, appliance grade, factory assembled air-conditioner unit. Unit shall be in accordance with AHAM Directory and UL 484. Units shall include a self-contained, precharged, slide-in and removable chassis-mounted, air-cooled refrigeration system. Cooling section shall be equipped with a filter-drier on the suction line. Fan and condenser motors shall have

[open] [dripproof] [totally enclosed] [explosion proof] enclosures.

2.5.2 Packaged Terminal Unit

Unit shall be a through-the-wall mounted, heavy-duty commercial grade, factory assembled and precharged [air-conditioner] [heat pump] unit. Unit shall be in accordance with ARI 310/380 and UL 1995. Units shall be removable from inside the building for servicing without removing the outside cabinet. Unit shall have a noise rating in accordance with ARI 350 and not exceed [_____] bels while the entire unit is operating at any fan or compressor speed. Heat pump units shall contain a reversing valve to change unit to heating cycle. An outdoor coil temperature sensor shall be provided to guard against coil freeze-up by either switching to supplemental heat only, or by cycling the compressor to defrost the coil.

2.5.3 Compressor

Compressor shall be hermetically sealed reciprocating, rotary, or scroll type. Compressor shall be fitted with permanent split capacitor motor, overload protection, and vibration isolators. Compressor shall be protected against high discharge pressure, loss of charge, low voltage, and short cycling.

2.5.4 Air-To-Refrigerant Coils

****

NOTE: Delete the copper or aluminum tubes and the 0.076 mm (3 mil) coating except in corrosive environments.

****

Evaporator and condenser coils shall have [nonferrous] [copper or aluminum] tubes of 10 mm (3/8 inch) 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Coils shall be protected with a minimum 0.076 mm 3 mil thick [phenolic] [or] [vinyl] coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. A condensate removal system shall be provided.

2.5.5 Fans

Indoor and outdoor fans shall be the centrifugal, direct driven type. Fans shall be statically and dynamically balanced. Outdoor fan shall be designed so that condensate will evaporate without drip, splash, or spray on building exterior. Indoor fan shall be provided with a minimum two-speed motor with built-in overload protection. Fan motors shall be the inherently protected, permanent split-capacitor type.

2.5.6 Air Filters

Filters shall be of the sectional or panel cleanable type and be capable of filtering the entire air supply.

2.5.7 Primary/Supplemental Heat

[Primary] [Supplemental] heat shall be provided as specified in paragraph "System Components".

2.5.8 Cabinet Construction

****
NOTE: The cabinet subbase is optional and should be deleted if not necessary.
****

Cabinet shall be free of visible fasteners, sharp protuberances and edges. Enclosure sheet metal shall be a minimum of 1.2 mm (18 gauge) 18 gauge steel with a protective coating. Face panels shall be removable and shall provide full access to unit appurtenances. Access to controls shall be without removal of the face panel. Conditioned air shall discharge through adjustable louvers. Cabinet shall be thermally and acoustically insulated with materials which conform to NFPA 90A. Units shall be furnished with a [field-wired] [prewired] subbase. Subbase shall have leveling screws [with] [without] provisions for remote unit control. Subbase shall be of 1.3 mm (18 gauge) 18 gauge galvanized steel construction with a protective coating to match that of the room cabinet. Paint and finishes shall comply with the requirements specified in paragraph "Factory Coating".

2.5.9 Wall Sleeve

Louver shall be stormproof type, constructed of anodized, stamped or extruded aluminum. Sleeve shall be a water and airtight [completely insulated] [noninsulated] assembly, with weather-resistant protective coating.

2.5.10 Duct Package

Duct extension shall consist of 1.3 mm (18 gauge) 18 gauge minimum galvanized steel plenum extender with all necessary internal dampers and baffles to divert [_____] percent of the supply air as indicated. Duct extension shall be painted with a protective coating that matches room cabinet.

2.5.11 Unit Controls

Controls shall include an on-off switch, high and low selector switch for [the cooling mode] [both the heating and cooling mode], multiple speed fan [cooling] [cooling and heating] mode, room air fan switch, outside air damper control, and an adjustable cooling [only] [and heating] thermostat. Function and temperature controls shall be [integral to unit] [remotely mounted as indicated or as accepted by the Contracting Officer].

2.6 UNITARY EQUIPMENT, PACKAGE SYSTEM

****

NOTE: Air-cooled, water-cooled, and evaporatively-cooled air-conditioning units with capacities less than 39.5 kW (135,000 Btuh) will be rated in accordance with ARI 210/240.

Air-cooled, water-cooled, and evaporatively-cooled air-conditioning and heat pump units with capacities greater than or equal to 39.5 kW (135,000 Btuh) will be rated in accordance with ARI 340/360.

Air-cooled heat pump units with capacities less than 39.5 kW (135,000 Btuh) will be rated in accordance with ARI 210/240.

Water-cooled heat pumps used in closed water loop systems (water-source systems) will be rated in accordance with ARI 320.

Water-cooled heat pumps used in open ground water loop systems (groundwater-source systems) will be rated in accordance with ARI 325. Delete the last 2 sentences if an open-loop type unit is not specified.

Specify a sound rating of 8.4 bels for outdoor units with capacities below 11.1 kW (38,000 Btuh). Specify a sound rating of 8.6 bels for outdoor units with capacities between 11.1 kW (38,000 Btuh) and 19 kW (65,000 Btuh). Specify a sound rating of 8.8 bels for outdoor units with capacities greater than 19 kW (65,000 Btuh). Specify ARI 270 for sound ratings for outdoor units with capacities less than 39.5 kW (135,000 Btuh), otherwise specify ARI 370.

Include the last sentence only if a water-cooled unit is specified and the supply water temperature is capable of falling below 65 degrees F in any mode of heat pump operation.

At a minimum, efficiencies for packaged systems will be in accordance with paragraph "Equipment Efficiency". Package systems are typically available in 2 different efficiency ranges; conventional efficiency and high efficiency. Conventional efficiency units typically have an EER value between 8.5 and 9.5 depending upon the size of the unit. High efficiency units typically have an EER value between 9.5 and 13.0. The efficiency to specify for a packaged system will be based upon an economic comparison. Coordinate the efficiency specified with manufacturers.

****

Unit shall be an [air-cooled] [water-cooled] [evaporatively-cooled] factory assembled, [weatherproof] [indoor] packaged unit as indicated. Unit shall be the [air-conditioning] [heat pump] type conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit shall be rated in accordance with [ARI 210/240] [ARI 340/360] [ARI 320] [ARI 325]. Unit shall be provided with equipment as specified in paragraph "System Components". Evaporator or supply fans shall be double-width, double inlet, forward curved, backward inclined, or airfoil blade, centrifugal scroll type. Motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures. Condenser fans shall be manufacturer's standard for the unit specified and may be either propeller or centrifugal scroll type. Unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged with refrigerant and oil in accordance with manufacturer's recommendations. Outdoor unit shall produce a maximum ARI sound rating of [8.4] [8.6] [8.8] [_____] bels in accordance with [ARI 270] [ARI 370]. [Interior water source piping shall be insulated as a "cold pipe" described in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.] [Water-cooled unit shall be fitted with a strainer protected solenoid shut-off valve. The valve shall be a fully automatic, self-contained temperature regulating valve with integral thermometer.]

2.6.1 Air-to-Refrigerant Coils

****

NOTE: Delete the copper or aluminum tubes and the 0.076 mm (3 mil) coating except in corrosive environments.

****

Air-to-refrigerant coils shall have [nonferrous] [copper or aluminum] tubes of 10 mm (3/8 inch) 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Coils shall be protected with a minimum 0.076 mm 3 mil thick [phenolic] [or] [vinyl] coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.6.2 Water-to-Refrigerant Coils

****

NOTE: Delete this paragraph if water-cooled packaged units are not specified. Delete the inapplicable fouling factor. In areas where poor water conditions exist or where water conditions are unknown, the 0.001 factor will be specified. In areas where water is known to be noncorrosive the 0.0005 fouling factor will be specified. Water-cooled condensers may be used for refrigerant

storage in lieu of a separate liquid receiver, if the condenser storage capacity is 20 percent in excess of the fully charged system.

****

Coils shall be of the tube-in-tube, shell-and-coil, shell-and-tube, or concentric tube type and be provided as an integral part of the packaged unit. Water-wetted metals shall be [copper] [or] [90/10] [or] [70/30] [copper-nickel], except that heads may be ferrous metal in systems with chemically treated recirculating water. Coils shall be rated for not less than 2758 kPa (400 psi) 400 psi refrigerant side and 862 kPa (125 psi) 125 psi water side pressure service at operating temperatures. Coils shall be supplied with water as indicated. Water supply, return and control system wetted parts shall be copper, bronze or stainless steel. Water supply, return connections and piping internal to unit shall be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement shall include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Performance shall be based on an allowable water velocity not less than 0.9 m/s (3 fps) 3 fps nor more than 3 m/s (10 fps) 10 fps with a fouling factor of [0.001] [0.0005].

2.6.3 Evaporatively-Cooled Section

****

NOTE: Delete this paragraph and subparagraphs if an evaporatively-cooled packaged unit is not specified.

****

The evaporative section shall be a packaged component of the unitary equipment. Unit shall be the counter-flow blow-through design, with single-side air entry. Unit shall have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section, the cabinet, etc. shall be not lighter than 16-gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A 153/A 153M and ASTM A 123/A 123M, as applicable and a minimum coating thickness of 0.76 kg/square meter (2-1/2 ounces per square foot) 2-1/2 ounces per square foot of surface. Cut edges shall be given a protective coating of zinc-rich compound. After assembly, the manufacturer's standard zinc chromatized aluminum or epoxy paint finish shall be applied to the exterior of the unit.

2.6.3.1 Pan Section

The pan shall be watertight and be provided with drain, overflow, and make-up water connections. Standard pan accessories shall include circular access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

2.6.3.2 Fan Section

Fan shall be the [centrifugal] [propeller] type in accordance with paragraph "Fans". Fan and fan motor shall not be located in the discharge airstream of the unit. Motors shall have [open] [splashproof] [totally

enclosed] enclosure and be suitable for the indicated service. The unit design shall prevent water from entering into the fan section.

2.6.3.3 Condensing Coil

****
NOTE: Delete the copper or aluminum tubes and the 0.076 mm (3 mil) coating except in corrosive environments.
****

Coils shall have [nonferrous] [copper or aluminum] tubes of 10 mm (3/8 inch) 3/8 inch minimum diameter without fins. Coils shall be protected with a minimum 0.076 mm (3 mil) 3 mil thick [phenolic] [or] [vinyl] coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system.

2.6.3.4 Water Distribution System

Water shall be distributed uniformly over the condensing coil to ensure complete wetting of the coil at all times. Spray nozzles shall be brass, stainless steel, or high-impact plastic. Nozzles shall be the cleanable, nonclogging, removable type. Nozzles shall be designed to permit easy disassembly and be arranged for easy access.

2.6.3.5 Water Pump

The water pump shall be the bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the unit or remotely on a separate mounting pad. Pumps shall have cast-iron casings. Impellers shall be bronze, and shafts shall be stainless steel with bronze casing wearing rings. Shaft seals shall be the mechanical type. Pump casing shall be factory coated with epoxy paint. Pump motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures. A bleed line with a flow valve or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge. Pump suction shall be fully submerged and provided with a galvanized steel or monel screened inlet.

2.6.3.6 Drift Eliminator

Eliminators shall be provided to limit drift loss to not over 0.005 percent of the specified water flow. Eliminators shall be constructed of zinc-coated steel or polyvinyl chloride (PVC). Eliminators shall prevent carry over into the unit's fan section.

2.6.3.7 Evaporator Controls

Unit shall be provided with modulating capacity control dampers mounted in the discharge of the fan housing. On a decrease in refrigerant discharge pressure the dampers shall modulate to reduce the airflow across the condensing coil. Controls shall include a proportional acting pressure

controller, a control transformer, motor actuator with linkages and end switches to cycle fan motor on and off. Cycling of a fan motor on and off shall be in accordance with the manufacturer.

2.6.4 Compressor

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 35 kW (10 tons) 10 tons and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors shall operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Compressors shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, thermal overloads, [lubrication pump,] [high] [high and low] pressure safety cutoffs and protection against short cycling.

2.6.5 Refrigeration Circuit

****
NOTE: Filter-driers are optional and may be deleted on most precharged systems.
****

Refrigerant containing components shall comply with ASHRAE 15 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve.

2.6.6 Unit Controls

****
NOTE: Insert in the blank appropriate minimum or lowest expected ambient temperature. Delete head pressure controls if inapplicable. Delete low cost cooling if inapplicable. In those areas where the outdoor seasonal climatic conditions permit, an outdoor temperature sensing unit (dry bulb) may be used in an external control circuit to take advantage of outside air to satisfy the cooling load. Under such conditions, the control circuit would lock out the compressors and position the outdoor and return air dampers to allow 100 percent fresh air to be circulated. Enthalpy controls will not be used.
****

Unit shall be internally prewired with a [24] [120] [_____] volt control circuit powered by an internal transformer. Terminal blocks shall be provided for power wiring and external control wiring. Unit shall have cutoffs for [high] [high and low] pressure, [and] low oil pressure for compressors with positive displacement oil pumps, [supply fan failure] [and safety interlocks on all service panels]. Head pressure controls shall sustain unit operation with ambient temperature of [_____]. Adjustable-cycle timers shall prevent short-cycling. Multiple compressors shall be staged by means of a time delay. Unit shall be internally protected by fuses or a circuit breaker in accordance with UL 1995. Low cost cooling shall be made possible by means of a control circuit which will modulate dampers to provide 100 percent outside air while locking out compressors.

2.7 UNITARY EQUIPMENT, SPLIT SYSTEM

****

NOTE: A remote condensing unit includes both the condensing coil and the compressor. A remote condenser includes only the condensing coil.

Air-cooled, water-cooled, and evaporatively-cooled air-conditioning units with capacities less than 39.5 kW (135,000 Btuh) will be rated in accordance with ARI 210/240.

Air-cooled, water-cooled, and evaporatively-cooled air-conditioning and heat pump units with capacities greater than or equal to 39.5 kW (135,000 Btuh) will be rated in accordance with ARI 340/360.

Air-cooled heat pump units with capacities less than 39.5 kW (135,000 Btuh) will be rated in accordance with ARI 210/240.

Water-cooled heat pumps used in closed water loop systems (water-source systems) will be rated in accordance with ARI 320.

Water-cooled heat pumps used in open ground water loop systems (groundwater-source systems) will be rated in accordance with ARI 325.

At a minimum, efficiencies for split-systems will be in accordance with paragraph "Equipment Efficiency". Single phase split systems are typically available with SEER values of 10, 11, 12, or 14. Three phase split systems are typically available in 2 different efficiency ranges; conventional efficiency and high efficiency. Conventional efficiency units typically have an EER value between 8.5 and 9.5 depending upon the size of the unit. High efficiency units typically have an EER value between 9.5 and 13.0.

The efficiency to specify for a split-system will be based upon an economic comparison. Coordinate the efficiency specified with manufacturers.

****

Unit shall be an [air-cooled] [water-cooled] [evaporatively-cooled], split system which employs a remote [condenser] [condensing unit], a separate indoor unit, and interconnecting refrigerant piping. Unit shall be the [air-conditioning] [heat pump] type conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit shall be rated in accordance with [ARI 210/240] [ARI 340/360] [ARI 320] [ARI 325]. Unit shall be provided with necessary fans, air filters, [coil frost protection,] [liquid receiver,] internal dampers, mixing boxes, supplemental heat, and cabinet construction as specified in paragraph "System Components". The remote unit shall be as specified in paragraph REMOTE CONDENSER OR CONDENSING UNIT. Evaporator or supply fans shall be double-width, double inlet, forward curved, backward inclined, or airfoil blade, centrifugal scroll type. Condenser or outdoor fans shall be the manufacturer's standard for the unit specified and may be either propeller or centrifugal scroll type. Fan and condenser motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures.

2.7.1 Air-to-Refrigerant Coil

****

NOTE: Delete the copper or aluminum tubes and the 0.076 mm (3 mil) coating except in corrosive environments.

****

Coils shall have [nonferrous] [copper or aluminum] tubes of 10 mm (3/8 inch) 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Coils shall be protected with a minimum 0.076 mm 3 mil thick [phenolic] [or] [vinyl] coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.7.2 Compressor

****

NOTE: Delete this paragraph if a remote condensing unit is specified.

****

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 35 kW (10 tons) 10 tons and larger shall be provided with capacity reduction devices to produce automatic

capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, thermal overloads, [lubrication pump,] [high] [high and low] pressure safety cutoffs and protection against short cycling.

2.7.3 Refrigeration Circuit

****

NOTE: Filter-driers are optional and may be deleted on most precharged systems. Delete the last two sentences if an integral water-cooled condenser is not specified.

****

Refrigerant-containing components shall comply with ASHRAE 15 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. A refrigerant suction line [thermostatic] [thermostatic and water flow switch] control shall be provided to prevent freeze-up in event of loss of water flow during heating cycle.

2.7.4 Unit Controls

****

NOTE: Insert in the blank appropriate minimum or lowest expected ambient temperature. Delete head pressure controls if inapplicable. Delete low cost cooling if inapplicable. In those areas where the outdoor seasonal climatic conditions permit, an outdoor temperature sensing unit (dry bulb) may be used in an external control circuit to take advantage of outside air to satisfy the cooling load. Under such conditions, the control circuit would lock out the compressors and position the outdoor and return air dampers to allow 100 percent fresh air to be circulated. Enthalpy controls will not be used.

****

Unit shall be internally prewired with a [24] [120] [_____] volt control circuit powered by an internal transformer. Terminal blocks shall be provided for power wiring and external control wiring. Unit shall have cutoffs for [high] [high and low] pressure, [and] low oil pressure for compressors with positive displacement oil pumps, [supply fan failure],

[and safety interlocks on all service panels]. Head pressure controls shall sustain unit operation with ambient temperature of [_____] degrees C ([_____] degrees F).[_____] degrees F. Adjustable-cycle timers shall prevent short-cycling. Multiple compressors shall be staged by means of a time delay. Unit shall be internally protected by fuses or a circuit breaker in accordance with UL 1995. Low cost cooling shall be made possible by means of a control circuit which will modulate dampers to provide 100 percent outside air while locking out compressors.

****

NOTE: The equipment listed below represent the recommended manufacturer's products by the Army Reserve. Edit the applicable manufacturer references and model references in the clauses below. Designers shall use professional judgement and up-to-date manufacturer information when revising this list.

****

2.7.5 Acceptable Manufacturers Of Unitary Equipment, Split System

Carrier Corp., Model [_____].
Snyder General Corp., Model [_____].
Trane Company, Model [_____].
York International Corp., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.8 AIR-CONDITIONERS FOR ELECTRONIC DATA PROCESSING (EDP) SPACES

****

NOTE: Indoor units are inherently noisy. In noise sensitive areas, steps should be taken to attenuate sound.

Air-cooled and water-cooled air-conditioning units with capacities less than 39.5 kW (135,000 Btuh) will be rated in accordance with ARI 210/240.

Air-cooled, water-cooled, and evaporatively-cooled air-conditioning units with capacities greater than or equal to 39.5 kW (135,000 Btuh) will be rated in accordance with ARI 340/360.

Delete the last sentence if an integral water-cooled condenser or a packaged air-cooled unit is specified.

Inapplicable equipment and system requirements will be deleted or modified in all paragraphs to suit the system designed. Coordinate the standard and design option features typical for each Air-Conditioner/Heat Pump unit and individual installation. Care must be taken to avoid specifying design options which are generally unavailable in certain combinations or are inappropriate for the application.

****

Unit shall be an [air-cooled] [water-cooled], self-contained type air-conditioning unit. Unit shall be [a packaged unit with an internal water-cooled condenser] [a split-system with a remote [condenser] [condensing unit]]. Unit shall be designed and constructed for automatic control of space conditions. Unit shall be in accordance with ASHRAE 127 and UL 1995. Unit shall be rated in accordance with [ARI 210/240] [ARI 340/360]. ARI certification is not required. The system shall be designed and constructed for maximum reliability and ease of maintenance. Necessary redundancy, access to refrigeration circuits, means of troubleshooting, and malfunction alarms shall be provided. Unit shall be provided with necessary fans, air filters, [coil frost protection,] [liquid receiver,] internal dampers, mixing boxes, supplemental heat, and cabinet construction as specified in paragraph "System Components". Evaporator or supply fans shall be double-width, double inlet, forward curved centrifugal scroll type. Condenser or outdoor fans shall be manufacturer's standard for unit specified and may be either propeller or centrifugal scroll type. Fan and condenser motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures. [Remote unit shall be as specified in paragraph REMOTE CONDENSER/CONDENSING UNIT.]

2.8.1 Air-to-Refrigerant Coils

****

NOTE: Delete the copper or aluminum tubes and the 0.076 mm (3 mil) coating except in corrosive environments.

****

[Evaporator] [Evaporator and condenser] coils shall have [nonferrous] [copper or aluminum] tubes of 10 mm (3/8 inch) 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Coils shall be protected with a minimum 0.076 mm 3 mil thick [phenolic] [or] [vinyl] coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Units shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.8.2 Water-to-Refrigerant Coils

****

NOTE: Delete this paragraph if a remote condenser/condensing unit is specified. Delete the last two sentences if a once-thru water source is not used in conjunction with the self-contained unit.

Delete the inapplicable fouling factor. In areas where poor water conditions exist or where water conditions are unknown, the 0.001 factor will be specified. In areas where water is known to be

noncorrosive the 0.0005 fouling factor will be specified. The inapplicable fouling factor will be deleted. Water-cooled condensers may be used for refrigerant storage in lieu of a separate liquid receiver, if the condenser storage capacity is 20 percent in excess of the fully charged system.

****

Unit shall be of the tube-in-tube, shell-and-coil, shell-and-tube, or concentric tube type and be provided as an integral part of the self-contained unit. Water-wetted metals shall be [copper] [or] [90/10] [or] [70/30] [copper-nickel], except that heads may be ferrous metal in systems with chemically treated recirculating water. Unit shall be rated for not less than 2758 kPa (400 psi) 400 psi refrigerant side and 862 kPa (125 psi) 125 psi water side pressure service at operating temperatures. Unit shall be supplied with water as indicated. Water supply, return and control system wetted parts shall be copper, bronze or stainless steel. Water supply, return connections and piping internal to unit shall be copper with brazed or threaded copper or bronze fittings, terminating in a threaded connection. Piping arrangement shall include valved access for recirculation of acidic scale removal chemicals and isolation pressure taps to determine pressure drop and water flow. Performance shall be based on an allowable water velocity not less than 0.9 m/s (3 fps) 3 fps nor more than 3 m/s (10 fps) 10 fpswith a fouling factor of [0.001] [0.0005]. A separate condenser shall be provided for each compressor circuit. Control shall be set for refrigerant condensing temperature of [_____] degrees C ([_____] degrees F).[_____] degrees F. Units which use a once-thru water-source shall be fitted with a strainer protected solenoid shut-off valve. The valve shall be a fully automatic, self-contained temperature regulating valve with integral thermometer.

2.8.3 Compressor

****

NOTE: Delete this paragraph if a remote condensing unit is specified.

****

Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Compressors of 26 kW (7-1/2 tons) 7-1/2 tons and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, [lubrication pump,] thermal overloads, and [high] [high and low] pressure safety cutoffs and protection against short cycling.

2.8.4 Refrigeration Circuit

****
NOTE: Filter-driers are optional and may be deleted on most precharged systems. Delete the last two sentences except when needed for a self-contained heat pump with an integral water-cooled condenser.
****

Refrigerant-containing components shall comply with ASHRAE 15 and be factory tested, cleaned, dehydrated, charged, and sealed. Refrigerant charging valves and connections, and pumpdown valves shall be provided for each circuit. Filter-drier shall be provided in each liquid line and be reversible-flow type. Refrigerant flow control devices shall be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. A refrigerant suction line [thermostatic] [thermostatic and water flow switch] control shall be provided to prevent freeze-up in event of loss of water flow during heating cycle.

2.8.5 Unit Controls

A unit's basic functions and space ambient conditions shall be controllable at one station. A temperature and humidity strip-chart recorder, integral or external to the unit, readable to specified control accuracy, shall be provided, complete with cartridge ink and chart supply for 1 year of operation.

2.8.5.1 Externally Accessible Controls

The following controls shall be externally accessible:

a. Start and stop total system functions.

b. Audible alarm silence.

c. Main power disconnect.

2.8.5.2 Status Indicators

The following status indicators shall be externally visible:

a. Power On.

b. System On.

c. Malfunction.

d. Provision for remote alarm status indication.

2.8.5.3 Alarmed Conditions

The following system status conditions shall be both audibly and visually alarmed:

a. Loss of air flow.

b. Dirty filters.

c. Compressor overload or lock-out (compressor high head pressure and low suction pressure).

d. [High] [High and low] room temperature.

e. High humidity alarm at [_____] percent relative humidity.

2.8.5.4 Space Temperature

Space temperature shall be controlled within plus or minus 1 degrees C 1-1/2 degrees F of the set point over a range of 16 to 32 degrees C (60 to 90 degrees F) 60 to 90 degrees F with a set point of [_____]. Space relative humidity shall be controlled within plus or minus 5 percent of the set point over a range of 20 to 80 percent with a set point of [_____] percent.

2.8.5.5 Safety Controls

Safety controls shall include the following:

a. Fused, unfused or line-break circuit breaker disconnects, as indicated or required.

b. Automatic pump-out or pump-down liquid flooding controls.

c. High refrigerant pressure cutout.

d. Low refrigerant pressure cutout where automatic pump-down is not provided.

e. Accessible hermetic and open compressor low oil pressure cutout.

f. Elapsed time meter for each compressor where load equalization is not incorporated.

g. Lead and lag compressor selector switch, when compatible with system.

2.8.6 Cabinet Construction

****
NOTE: Delete the last sentence if inapplicable.
****

Cabinet shall be totally enclosed. Enclosure surfaces shall be pulsation free, with hinged and removable doors and panels for vertical side or front access to unit components. Routine maintenance access to compressor and system control components shall be possible without unit shut-down. Enclosure surfaces shall be thermally and acoustically insulated. Interior

baffle and compartment surfaces shall be galvanized steel. Drain pans shall collect all condensate and be steel with external insulation as required. Surface mounting steel pads and vibration isolating pads shall be provided. Enclosure surfaces shall be prepared, primed and finished. Paint and finishes shall comply with the requirements specified in paragraph "Factory Coating". Cabinets shall be fitted with integral or separable, adjustable and lockable jacks to support the units from the structural slab at the raised-floor elevation.

2.9 EQUIPMENT EFFICIENCY

****

NOTE: Use this note to determine the minimum equipment efficiencies required for all equipment specified. Present applicable efficiencies either in this paragraph or on the design drawings. Delete this paragraph if equipment efficiencies are shown on the drawings.

The following is a list of terms which are commonly used in regard to efficiency ratings.

COP - Coefficient of Performance (dimensionless)
EER - Energy Efficiency Ratio (Btuh/Watt)
HSPF - Heating System Performance Factor (Btuh/Watt)
SEER - Seasonal Energy Efficiency Ratio (Btuh/Watt)
SCOP - Seasonal Coefficient of Performance (dimensionless)
IPLV - Integrated Part Load Value (dimensionless)

COP and HSPF values are typically used in regard to heating efficiencies. COP values should also be used to define cooling efficiencies when a job is being specified in SI units (EER = 3.415 x COP). COP and EER values are established based strictly upon a unit's full load capacity and not part load capacities.

Equipment selected will have as a minimum the efficiency rating determined in the following paragraphs. The minimum efficiencies will be determined based upon the standards referenced (i.e. ARI 210/240, ARI 340/360, etc.) Equipment having a higher efficiency may be specified if the designer determines the equipment to be more life-cycle cost effective.

ARI 210/240: The following is a list of minimum efficiencies for equipment rated in accordance with ARI 210/240 (Packaged Unitary Systems, Split Unitary Systems, and EDP Air-Conditioners). The efficiencies are based on the standard ratings conditions defined in ARI 210/240.

AIR-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity less than 19 kW (less than 65,000 Btuh)
Cooling Mode
SEER = 10.0 (1 Phase)
EER = 9.5 (3 Phase)
IPLV = 8.5 (3 Phase)
Heating Mode
HSPF = 6.6 (1 Phase)
COP = 3.0 (High Temp Rating, 3 Phase)
COP = 2.0 (Low Temp Rating, 3 Phase)

Capacity greater than or equal to 19 kW and less than 39.5 kW (greater than or equal to 65,000 and less than 135,000 Btuh)
Cooling Mode
EER = 8.9 (All Phases)
IPLV = 8.3 (All Phases)
Heating Mode
COP = 3.0 (High Temperature Rating, All Phases)
COP = 2.0 (Low Temperature Rating, All Phases)

EVAPORATIVELY-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity less than 19 kW (less than 65,000 Btuh)
Cooling Mode
EER = 9.3

Capacity greater than or equal to 19 kW and less than 39.5 kW (greater than or equal to 65,000 and less than 135,000 Btuh)
Cooling Mode
EER = 10.5

WATER-COOLED, SPLIT AND PACKAGED SYSTEMS
Capacity less than 19 kW (less than 65,000 Btuh)
Cooling Mode
EER = 9.3
IPLV = 8.3

Capacity greater than or equal to 19 kW and less than 39.5 kW (greater than or equal to 65,000 and less than 135,000 Btuh)
Cooling Mode
EER = 10.5

ARI 340/360: The following is a list of minimum efficiencies for equipment rated in accordance with ARI 340/360 (Packaged Unitary Systems, Split Unitary Systems, and EDP Air-Conditioners). The efficiencies are based on the standard ratings conditions defined in ARI 340/360.

COMMERCIAL UNITARY AIR CONDITIONER

AIR-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity greater than or equal to 19 kw (65,000 Btuh) and less than or equal to 39.5 kw (135,000 Btuh)
EER = 10.3 or more

COMMERCIAL UNITARY AIR CONDITIONER
AIR-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity greater than or equal to 39.5 kw (135,000 Btuh) and less than or equal to 70.3 kw (240,000 Btuh)
EER = 9.7 or more

COMMERCIAL UNITARY AIR CONDITIONER
AIR-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity greater than 70.3 kw (240,000 Btuh
EER = 10.0 or more.

COMMERCIAL UNITARY AIR CONDITONER
WATER-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity greater than or equal to 19 kw (65,000 Btuh) and less than or equal to 39.5 kw (135,000 Btuh)
EER = 11.5 or more

COMMERCIAL UNITARY AIR CONDITIONER
WATER-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity greater than 39.5 kw (135,000 Btuh)
EER = 11.0 or more

COMMERCIAL UNITARY HEAT PUMP
AIR-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity greater than or equal to 19 kw (65,000 Btuh) and less than or equal to 39.5 kw (135,000 Btuh)
EER = 10.1 or more
COP = 3.1 or more

COMMERCIAL UNITARY HEAT PUMP
AIR-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity greater than or equal to 39.5 kw (135,000 Btuh) and less than or equal to 70.3 kw (240,000 Btuh)
EER = 9.3 or more
COP = 3.1 or more

COMMERCIAL UNITARY HEAT PUMP
WATER-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity greater than or equal to 19 kw (65,000 Btuh) and less than or equal to 39.5 kw (135,000 Btuh)
EER = 13.0 or more
COP = 4.5 or more

ARI 320: The following is a list of minimum efficiencies for equipment rated in accordance with ARI 320 (Water-source heat pumps used in Packaged and Split Unitary Systems). The efficiencies are based on the standard ratings conditions defined in ARI 320.

WATER-COOLED, SPLIT AND PACKAGE SYSTEMS
Capacity less than 19 kW (less than 65,000 Btuh)
Cooling Mode
EER = 9.3 (Standard Rating)
EER = 10.2 (Low Temp. Rating)
Heating Mode
COP = 3.8 (Standard Rating)
COP = 3.4 (High Temp Rating)
COP = 3.0 (Low Temp Rating)

Capacity greater than or equal to 19 kW (greater than or equal to 65,000 Btuh)
Cooling Mode
EER = 10.5 (Standard Rating)
Heating Mode
COP = 3.8 (Standard Rating)
COP = 3.4 (High Temp Rating)
COP = 3.0 (Low Temp Rating)

ARI 325: The following is a list of minimum efficiencies for equipment rated in accordance with ARI 325 (Groundwater-source heat pumps used in Packaged and Split Unitary Systems). The efficiencies are based on the standard ratings conditions defined in ARI 325.

GROUNDWATER-COOLED, SPLIT AND PACKAGE SYSTEMS
Cooling Mode (All Capacities)
EER = 11.0 (Standard Rating)
EER = 11.5 (Low Temp. Rating)

Heating Mode (All Capacities)
COP = 3.8 (Standard Rating)
COP = 3.4 (High Temp Rating)
COP = 3.0 (Low Temp Rating)

ARI 310/380: The following is a list of minimum efficiencies for equipment rated in accordance with ARI 310/380 (Packaged Terminal Units). The efficiencies are based on the standard ratings conditions defined in ARI 310/380.

PACKAGED TERMINAL UNITS

Cooling Mode
Capacity less than or equal to 2.0 kW (less than or equal to 7,000 Btuh)
EER = 9.5
Capacity greater than 2.0 and less than or equal to 2.9 kW (greater than 7,000 and less than or equal to 10,000 Btuh)
EER = 9.0
Capacity greater than 2.9 and less than or equal to 3.5 kW (greater than 10,000 and less than or equal to 12,000 Btuh)
EER = 8.5
Capacity greater than 3.5 kW (greater than 12,000 Btuh)
EER = 8.0

Heating Mode (All Capacities)
COP = 2.7 (Standard Rating)

For multi-capacity equipment, the minimum performance shall apply to each capacity step provided and allowed by the controls.

AHAM Directory: The following is a list of minimum efficiencies for equipment rated in accordance with AHAM Directory (Window or Through-the-Wall Room Units). The efficiencies are based on the standard ratings conditions defined in AHAM Directory.

ROOM UNITS
Without Reverse Cycle and with Louvered Sides
Capacity less than or equal to 1.8 kW (less than 6,000 Btuh)
EER = 8.0
Capacity greater than 1.8 and less than or equal to 2.3 kW (greater than 6,000 and less than or equal to 8,000 Btuh)
EER = 8.5
Capacity greater than 2.3 and less than or equal to 4.0 kW (greater than 8,000 and less than or equal to 14,000 Btuh)
EER = 9.0
Capacity greater than 4.0 and less than or equal to 5.9 kW (greater than 14,000 and less than or equal to 20,000 Btuh)
EER = 8.8
Capacity greater than or equal to 5.9 kW (greater than 20,000 Btuh)
EER = 8.2

Without Reverse Cycle and without Louvered Sides
Capacity less than or equal to 1.8 kW (less than 6,000 Btuh)

EER = 8.0
Capacity greater than 1.8 and less than or equal to 5.9 kW (greater than 6,000 and less than or equal to 20,000 Btuh)
EER = 8.5
Capacity greater than or equal to 5.9 kW (greater than 20,000 Btuh)
EER = 8.0

With Reverse Cycle and With Louvered Sides
All Capacities
EER = 8.5

With Reverse Cycle and Without Louvered Sides
All Capacities
EER = 8.0

****

Unit shall have an efficiency [of[_____]] [as indicated on the drawings].

2.10 REMOTE CONDENSER OR CONDENSING UNIT

****
NOTE: Delete the sound requirements unless the unit is located in a sound-sensitive area.
****

Units with capacities less than 39.5 kW (135,000 Btuh) 135,000 Btuh shall produce a maximum ARI sound rating of [_____] bels when rated in accordance with ARI 270. Units with capacities 39.5 kW (135,000 Btuh) 135,000 Btuh or greater shall produce a maximum ARI sound rating of [_____] bels when rated in accordance with ARI 370. Each remote condenser coil shall be fitted with a manual isolation valve and an access valve on the coil side. Saturated refrigerant condensing temperature shall not exceed 49 degrees C (120 degrees F) 120 degrees F at 40 degrees C (95 degrees F) 95 degrees F ambient. Unit shall be provided with low ambient condenser controls to ensure proper operation in an ambient temperature of [_____] degrees C ([_____] degrees F). [_____] degrees F. Fan and cabinet construction shall be provided as specified in paragraph "System Components". Fan and condenser motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures.

2.10.1 Air-Cooled Condenser

Unit shall be rated in accordance with ARI 460 and conform to the requirements of UL 1995. Unit shall be factory fabricated, tested, packaged, and self-contained. Unit shall be complete with casing, propeller or centrifugal type fans, heat rejection coils, connecting piping and wiring, and all necessary appurtenances.

2.10.1.1 Connections

Interconnecting refrigeration piping, electrical power, and control wiring between the condensing unit and the indoor unit shall be provided as

required and as indicated. Electrical and refrigeration piping terminal connections between [condenser] [condensing unit] and evaporator units shall be provided.

2.10.1.2 Head Pressure Control and Liquid Subcooling

Low ambient control for multi-circuited units serving more than one evaporator coil shall provide independent condenser pressure controls for each refrigerant circuit. Controls shall be set to produce a minimum of 95 degrees F saturated refrigerant condensing temperature. Unit shall be provided with a liquid subcooling circuit which shall ensure proper liquid refrigerant flow to the expansion device over the specified application range of the condenser. Unit shall be provide with [manufacturer's standard] [not less than [4] [_____] degrees C ([8] [_____] degrees F) [8] [_____] degrees F] liquid subcooling. Subcooling circuit shall be liquid sealed.

2.10.1.3 Condensing Coil

****
NOTE: Delete the copper or aluminum tubes and the 0.076 mm (3 mil) coating except in corrosive environments.
****

Coils shall have [nonferrous] [copper or aluminum] tubes of 10 mm (3/8 inch) 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Coils shall be protected with a minimum 0.076 mm (3 mil) 3 mil thick [phenolic] [or] [vinyl] coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.10.1.4 Unit Controls

The control system shall be complete with required accessories for regulating condenser pressure by fan cycling, solid-state variable fan speed, modulating condenser coil or fan dampers, flooding the condenser, or a combination of the above. Unit mounted control panels or enclosures shall be constructed in accordance with applicable requirements of NFPA 70 and housed in NEMA ICS 6, Class 1 or 3A enclosures. Controls shall include [control transformer,] [fan motor [starters,]] [solid-state speed control,] [electric heat tracing controls,] [time delay start-up,] overload protective devices, interface with local and remote components, and intercomponent wiring to terminal block points.

2.10.2 Evaporative Condenser

Each unit shall be the counter-flow blow-through design, with single-side

air entry. The unit shall have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section, the cabinet, etc. shall be not lighter than 16-gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A 153/A 153M and ASTM A 123/A 123M, as applicable and have an extra heavy coating of not less than 0.76 kg/square meter (2-1/2 ounces per square foot) 2-1/2 ounces per square foot of surface. Cut edges shall be given a protective coating of zinc-rich compound. After assembly, the manufacturer's standard zinc chromatized aluminum or epoxy paint finish shall be applied to the exterior of the unit. Unit shall be rated in accordance with ARI 490 and tested in accordance with the requirements of ASHRAE 64.

2.10.2.1 Pan Section

The pan shall be watertight and be provided with drain, overflow, and make-up water connections. Standard pan accessories shall include circular access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

2.10.2.2 Fan Section

Fan shall be the [centrifugal] [propeller] type in accordance with paragraph "Fans". Fan and fan motor shall not be located in the discharge airstream of the unit. Motors shall have [open] [splashproof] [totally enclosed] enclosure and be suitable for the indicated service. The condensing unit design shall prevent water from entering into the fan section.

2.10.2.3 Condensing Coil

****

NOTE: Delete the copper or aluminum tubes and the 0.076 mm (3 mil) coating except in corrosive environments.

****

Coils shall have [nonferrous] [copper or aluminum] tubes of 10 mm (3/8 inch) 3/8 inch minimum diameter without fins. Coils shall be protected with a minimum 0.076 mm (3 mil) 3 mil thick [phenolic] [or] [vinyl] coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged.

2.10.2.4 Water Distribution System

Water shall be distributed uniformly over the condensing coil to ensure complete wetting of the coil at all times. Spray nozzles shall be brass, stainless steel, or high-impact plastic. Nozzles shall be the cleanable, nonclogging, removable type. Nozzles shall be designed to permit easy

disassembly and be arranged for easy access.

2.10.2.5 Water Pump

The water pump shall be the bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pumps shall have cast-iron casings. Impellers shall be bronze, and shafts shall be stainless steel with bronze casing wearing rings. Shaft seals shall be the mechanical type. Pump casing shall be factory coated with epoxy paint. Pump motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures. A bleed line with a flow valve or fixed orifice shall be provided in the pump discharge line and shall be extended to the nearest drain for continuous discharge. Pump suction shall be fully submerged and provided with a galvanized steel or monel screened inlet.

2.10.2.6 Drift Eliminator

Eliminators shall be provided to limit drift loss to not over 0.005 percent of the specified water flow. Eliminators shall be constructed of zinc-coated steel or polyvinyl chloride (PVC). Eliminators shall prevent carry over into the unit's fan section.

2.10.2.7 Unit Controls

The evaporative condenser unit shall be provided with modulating capacity control dampers mounted in the discharge of the fan housing. On a decrease in refrigerant discharge pressure the dampers shall modulate to reduce the airflow through the evaporative condenser. Controls shall include a proportional acting pressure controller, a control transformer, motor actuator with linkages and end switches to cycle fan motor on and off. Cycling of a fan motor on and off shall be in accordance with the manufacturer.

2.10.3 Compressor

****
NOTE: Delete this paragraph if only a remote condenser is required.
****

Unit shall be rated in accordance with ARI 500. Compressor shall be direct drive, semi-hermetic or hermetic reciprocating, or scroll type capable of operating at partial load conditions. Compressor shall be capable of continuous operation down to the lowest step of unloading as specified. Units 35 kW (120,000 Btuh) 120,000 Btuh and larger shall be provided with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors will operate in sequence, and each compressor shall have an independent refrigeration circuit through the condenser and evaporator. Each compressor shall start in the unloaded position. Each compressor shall be provided with vibration isolators, crankcase heater, [lubrication pump,] thermal overloads, and [high] [high

and low] pressure safety cutoffs and protection against short cycling.

2.10.4 Acceptable Manufacturers Of Remote Air-Cooled [Condenser] [or] [Condensing] Unit

Carrier Corp., Model [_____].
Snyder General Corp., Model [_____].
Trane Company, Model [_____].
York International Corp., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.11 DRY-COOLER, GLYCOL SOLUTION

Unit shall be factory fabricated and tested, packaged, self-contained, complete with casing, propeller or centrifugal type fans, heat rejection coils, appurtenances, and intercomponent piping and wiring. Unit shall be certified by the manufacturer or an independent test laboratory that the unit's ratings meet ARI 410 the indicated conditions. Unit shall be designed for [outdoor] [indoor] installation and comply with the requirements of UL 1995. Unit shall compatible with the solution specified in paragraph "Glycol Solution". Unit shall be fitted with [duplex] recirculating pump, expansion tank, [black steel] [Type L copper] [schedule 80 PVC] intercomponent piping, system accessories and controls. Factory assembled piping shall be Type L copper. Cabinet construction shall be in accordance with paragraph "System Components".

2.11.1 Coil

****
NOTE: Delete the copper or aluminum tubes and the 0.076 mm (3 mil) coating except in corrosive environments.
****

Coils shall have [nonferrous] [copper or aluminum] tubes of 10 mm (3/8 inch) 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Coils shall be protected with a minimum 0.076 mm (3 mil) 3 mil thick [phenolic] [or] [vinyl] coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance with ASHRAE 15 at the factory and be suitable for the working pressure of the installed system. Each coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Each unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.11.2 Fan Section

Fan shall be the [centrifugal] [propeller] type in accordance with paragraph "Fans". Motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures and be suitable for the indicated service.

2.11.3 Pump

Pump and controls shall be mounted within a lockable sheet metal enclosure supported from dry cooler structure. Pump shall be of the end-suction type with an [open] [dripproof] [totally enclosed] [explosion proof] motor. Pump construction shall be as specified in paragraph "Pumps". Seals shall be mechanical type suitable for ethylene glycol solution up to a 60 percent concentration of glycol, and be rated for 82 degrees C (180 degrees F) 180 degrees F service.

2.11.4 Controls

The control system shall be complete with all required accessories for regulating glycol temperature by [fan cycling.] [solid-state variable fan speed.] [modulating glycol 3-way mixing valve or modulating fan dampers.] Unit-mounted control panels or enclosures shall be constructed in accordance with applicable requirements of NFPA 70 and housed in NEMA ICS 6, Class 1 or 3A enclosures. Controls shall include a [control transformer,] [fan motor [starters,]] [solid-state speed control,] [pump motor starters,] [electric heat tracing controls,] [time delay start-up,] overload protective devices, interface with local and remote components, and intercomponent wiring to terminal block points.

2.12 SYSTEM COMPONENTS

****
NOTE: System components which are not referenced from the equipment specified above, excluding refrigerant and oil, will be deleted.
****

2.12.1 Refrigerant and Oil

****
NOTE: R-22, R-123 and R-134a all meet the ODP requirement of 0.05. R-22 is the most commonly used refrigerant.
****

Refrigerant shall be one of the fluorocarbon gases. Refrigerants shall have number designations and safety classifications in accordance with ASHRAE 34. Refrigerants shall meet the requirements of ARI 700 as a minimum. Refrigerants shall have an Ozone Depletion Potential (ODP) of less than or equal to 0.05. Contractor shall provide and install a complete charge of refrigerant for the installed system as recommended by the manufacturer. Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the system performance testing period. Following the satisfactory completion of the performance testing, the oil shall be drained and replaced with a second charge. Lubricating oil shall be of a type and grade recommended by the manufacturer for each compressor. Where color leak indicator dye is incorporated, charge shall be in accordance with manufacturer's recommendation.

2.12.2 Fans

Fan wheel shafts shall be supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Unit fans shall be selected to produce the cfm required at the fan total pressure. Motor starters, if applicable, shall be magnetic across-the-line type with a [open] [dripproof] [totally enclosed] [explosion proof] enclosure. Thermal overload protection shall be of the manual or automatic-reset type. Fan wheels or propellers shall be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings shall be of galvanized steel, and both centrifugal and propeller fan casings shall be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, shall be hot-dipped galvanized after fabrication or fabricated of mill galvanized steel. Mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting shall be recoated with an approved zinc-rich compound. Fan wheels or propellers shall be statically and dynamically balanced. Forward curved fan wheels shall be limited to [_____] inches. Direct-drive fan motors shall be of the multiple-speed variety. Belt-driven fans shall have adjustable sheaves to provide not less than [_____] percent fan-speed adjustment. The sheave size shall be selected so that the fan speed at the approximate midpoint of the sheave adjustment will produce the specified air quantity. Centrifugal scroll-type fans shall be provided with streamlined orifice inlet and V-belt drive. Each drive will be independent of any other drive. Propeller fans shall be [direct-drive] [V-belt] drive type with [adjustable] [fixed] pitch blades. V-belt driven fans shall be mounted on a corrosion protected drive shaft supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Each drive will be independent of any other drive. Drive bearings shall be protected with water slingers or shields. V-belt drives shall be fitted with guards where exposed to contact by personnel and [fixed pitch] [adjustable pitch] sheaves.

2.12.3 Primary/Supplemental Heating

****
NOTE: Inapplicable types of heating coils will be deleted. In some cases, unitary products are not available with steam or water heating coils.
****

2.12.3.1 Water Coil

****
NOTE: Drainable coils will be specified where coils are subject to freezing during the heating season. If drainable coils are not required, delete the last sentence.
****

Coil shall conform to the provisions of ARI 410. Coil shall be fin-and-tube type constructed of seamless copper tubes and [aluminum] [or] [copper] fins mechanically bonded or soldered to tubes. Headers shall be

constructed of cast iron, welded steel or copper. Coil shall be constructed to float within the casing to allow free expansion and contraction of tubing. Casing and tube support sheets shall not be lighter than 1.6 mm (16 gauge) 16 gauge galvanized steel formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Coil shall be circuited for suitable water velocity without excessive pressure drop and properly pitched for drainage where required or indicated. Each coil shall be tested at the factory under water at not less than 2000 kPa (300 psi) 300 psi air pressure, tested hydrostatically after assembly of the unit and proved tight under a gauge pressure of 1400 kPa (200 psi). 200 psi. Coil shall be suitable for use with water up to 120 degrees C. 250 degrees F. Coil shall allow complete coil drainage with a pitch of not less than 10 mm per meter 1/8 inch per foot slope to drain.

2.12.3.2 Steam Coil

Coil shall conform to the provisions of ARI 410. Coil shall be constructed of cast semi-steel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered. Tubes shall be rolled and bushed and brazed or welded into headers. Coil casings and tube support sheets, with collars of ample width, shall be not lighter than 1.6 mm (16 gauge) 16 gauge galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. The fin tube and header section shall float within the casing to allow free expansion of tubing for coils subject to high pressure-steam service. Coils shall be factory pressure tested and capable of withstanding 1700 kPa (250 psi) 250 psi hydrostatic test pressure or 1700 kPa (250 psi) 250 psi air pressure, and be for [700] [1400] kPa ([100] [200] psi) [100] [200] psi steam working pressure. Preheat coils shall be steam-distributing tube type. Condensing tubes shall be not less than 15 mm (5/8 inch) 5/8 inch outside diameter. Distribution tubes shall be not less than 10 mm (3/8 inch) 3/8 inch outside diameter, and be equipped with orifices to discharge steam to condensing tubes. Distribution tubes shall be installed concentrically inside of condenser tubes and be held securely in alignment. The maximum length of a single coil shall be limited to 120 times the diameter of the outside tube. Other heating coils shall be minimum 12 mm (1/2 inch 1/2 inch outside diameter single-tube type. Supply headers shall distribute steam evenly to all tubes at the indicated steam pressure. Coil shall allow complete coil drainage with a pitch of not less than 10 mm per meter 1/8 inch per foot slope to drain.

2.12.3.3 Electric Heating Coil

****

NOTE: Choose the second set of brackets if an air-conditioning unit for EDP is specified.

****

Coil shall be an electric duct heater in accordance with UL 1995 and NFPA 70. Coil shall be duct- or unit-mounted. Coil shall be of the [nickel chromium resistor, single stage, strip] [nickel chromium resistor, single stage, strip or stainless steel, fin tubular] type. Coil shall be provided

with a built-in or surface-mounted high-limit thermostat interlocked electrically so that the coil cannot be energized unless the fan is energized. Coil casing and support brackets shall be of galvanized steel or aluminum. Coil shall be mounted to eliminate noise from expansion and contraction and be completely accessible for service.

2.12.3.4 Gas Fired Heating Section

****
NOTE: Gas fired heating sections are not available for air-conditioning units for EDP spaces.
****

Gas fired heat exchanger shall be constructed of aluminized steel, ceramic coated cold-rolled steel or stainless steel suitable for [natural gas] [liquid propane gas] fuel supply. Burner shall have direct spark or hot surface ignition. Valve shall include a pressure regulator. Combustion air shall be supplied with a centrifugal combustion air blower. Safety controls shall include a flame sensor and air pressure switch. Heater section shall be mounted to eliminate noise from expansion and contraction and shall be completely accessible for service. Gas equipment shall bear the AGA label for the type of service involved. Burner shall be in accordance with NFPA 54.

2.12.3.5 Acceptable Manufacturers Of Primary/Supplemental Heating (Forced Air Furnace Units)

Carrier Corp., Model [_____].
Snyder General Corp., Model [_____].
Trane Company, Model [_____].
York International Corp., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.12.4 Air Filters

****
NOTE: References to inapplicable filter types will be deleted.
****

Air filters shall be listed in accordance with requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test Method shall be as listed under the label service and shall meet the requirements of UL 586.

2.12.4.1 Extended Surface Pleated Panel Filters

Filters shall be 50 mm (2 inch) 2 inch depth sectional type of the size indicated and shall have an average efficiency of 25 to 30 percent when tested in accordance with ASHRAE 52.1. Initial resistance at 2.54 m/s (500 feet per minute) 500 feet per minute will not exceed 90 Pa (0.36 inches water gauge). 0.36 inches water gauge. Filters shall be UL Class 2. Media shall be nonwoven cotton and synthetic fiber mat. A wire support grid

bonded to the media shall be attached to a moisture resistant fiberboard frame. Four edges of the filter media shall be bonded to the inside of the frame to prevent air bypass and increase rigidity.

2.12.4.2 Replaceable Media Filters

Replaceable media filters shall be the [dry-media] [viscous adhesive] type, of the size required to suit the application. Filtering media shall be not less than 50 mm (2 inches) 2 inches thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad shall be enclosed in a holding frame of not less than 1.6 mm (16 gauge) 16 gauge galvanized steel, and equipped with quick-opening mechanism for changing filter media. The air flow capacity of the filter shall be based on net filter face velocity not exceeding [1.52] [_____] m/s ([300] [_____] feet per minute), [300] [_____] feet per minute, with initial resistance of 32 Pa ([0.13] [_____] inches water gauge). [0.13] [_____] inches water gauge. Average efficiency shall be not less than [_____] percent when tested in accordance with ASHRAE 52.1.

2.12.4.3 Sectional Cleanable Filters

****
NOTE: Delete the last three sentences if a washing and cleaning unit is not necessary.
****

Cleanable filters shall conform to ASTM F 872, and be [25] [50] mm ([1 inch] [2 inches]) [1 inch] [2 inches] thick. Viscous adhesive shall be provided in 18.9 L (5 gallon) 5 gallon containers in sufficient quantity for 12 cleaning operations and not less than 1 L (one quart) one quart for each filter section. Initial pressure drop for clean filters shall not exceed the applicable values listed in ASTM F 872. One washing and charging tank shall be provided for every 100 filter sections or fraction thereof. Each washing and charging unit shall consist of a tank and [single] [double] drain rack mounted on legs. Drain rack shall be provided with dividers and partitions to properly support the filters in the draining position.

2.12.5 Coil Frost Protection

****
NOTE: If coil frost protection is required, manufacturer's recommended coil frost protection systems shall be evaluated. If the manufacturer's standard coil frost protection is not appropriate, determine if a hot gas bypass system is an economical and practical coil frost protection system and modify the specification as required.
****

Each circuit shall be provided with a coil frost protection system which is a manufacturer's standard. The coil frost protection system shall use a temperature sensor in the suction line of the compressor to shut the compressor off when coil frosting occurs. Timers shall be used to prevent

the compressor from rapid cycling.

2.12.6 Pressure Vessels

Pressure vessels shall conform to ASME BPV VIII Div 1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Where referenced publications do not apply, pressure components shall be tested at 1-1/2 times design working pressure. Refrigerant wetted carbon steel surfaces shall be pickled or abrasive blasted free of mill scale, cleaned, dried, charged, and sealed.

2.12.6.1 Hot Gas Muffler

Unit shall be selected by the manufacturer for maximum noise attenuation. Units rated for 100 kW (30 tons) 30 tons capacity and under may be field tunable type.

2.12.6.2 Liquid Receiver

A liquid receiver shall be provided when a system's condenser or compressor does not contain a refrigerant storage capacity of at least 20 percent in excess of a fully charged system. Receiver shall be designed, filled, and rated in accordance with the recommendations of ARI 495, except as modified herein. Receiver shall be fitted to include an inlet connection; an outlet drop pipe with oil seal and oil drain where necessary; two bull's-eye liquid level sight glass in same vertical plane, 90 degrees apart and perpendicular to axis of receiver or external gauge glass with metal guard and automatic stop valves; [thermal well for thermostat;] [float switch column;] [external float switches;] and purge, charge, equalizing, pressurizing, plugged drain and service valves on the inlet and outlet connections. Receiver shall be provided with a relief valve of capacity and setting in accordance with ASHRAE 15.

2.12.6.3 Oil Separator

Separator shall be the high efficiency type and be provided with removable flanged head for ease in removing float assembly and removable screen cartridge assembly. Pressure drop through a separator shall not exceed [70] [_____] kPa ([10] [_____] psi) [10] [_____] psi during the removal of hot gas entrained oil. Connections to compressor shall be as recommended by the compressor manufacturer. Separator shall be provided with an oil float valve assembly or needle valve and orifice assembly, drain line shutoff valve, sight glass, [filter for removal of all particulate sized 10 microns and larger,] [thermometer and low temperature thermostat fitted to thermal well,] [immersion heater,] [external float valve fitted with three-valve bypass,] and strainer.

2.12.6.4 Oil Reservoir

Reservoir capacity shall equal one charge of all connected compressors. Reservoir shall be provided with an external liquid gauge glass, plugged drain, and isolation valves. Vent piping between the reservoir and the suction header shall be provided with a 35 kPa (5 psi) 5 psi pressure differential relief valve. Reservoir shall be provided with the

manufacturer's standard filter on the oil return line to the oil level regulators.

2.12.7 Internal Dampers

****
NOTE: Specify the sequence of operation of all damper operations on the drawings.
****

Dampers shall be parallel blade type with renewable blade seals and be integral to the unitary unit. Damper provisions shall be provided for each outside air intake, exhaust, economizer, and mixing boxes. Dampers shall [have minimum position stops] [be linked together] [have [manual] [automatic] modulation] and operate as specified.

2.12.8 Mixing Boxes

Mixing boxes shall match the base unit in physical size and shall include equally-sized [flanged] openings, each capable of full air flow. Arrangement shall be as indicated.

2.12.9 Cabinet Construction

****
NOTE: Delete this paragraph if room air-conditioner/heat pumps or air-conditioners for EDP spaces are specified.
****

Casings for the specified unitary equipment shall be constructed of galvanized steel or aluminum sheet metal and galvanized or aluminum structural members. Minimum thickness of single wall exterior surfaces shall be 1.3 mm (18 gauge) 18 gauge galvanized steel or 1.8 mm (.071 inch) 071 inch thick aluminum on units with a capacity above 70 kW (20 tons) 20 tons and 1.0 mm (20 gauge) 20 gauge galvanized steel or 1.6 mm (0.064 inch) 0.064 inch thick aluminum on units with a capacity less than 70 kW (20 tons). 20 tons. Casing shall be fitted with lifting provisions, access panels or doors, fan vibration isolators, electrical control panel, corrosion-resistant components, structural support members, insulated condensate drip pan and drain, and internal insulation in the cold section of the casing. Where double-wall insulated construction is proposed, minimum exterior galvanized sheet metal thickness shall be 1.0 mm (20 gauge). 20 gauge. Provisions to permit replacement of major unit components shall be incorporated. Penetrations of cabinet surfaces, including the floor, shall be sealed. Unit shall be fitted with a drain pan which extends under all areas where water may accumulate. Drain pan shall be fabricated from Type 300 stainless steel, galvanized steel with protective coating as required, or an approved plastic material. Pan insulation shall be water impervious. Extent and effectiveness of the insulation of unit air containment surfaces shall prevent, within limits of the specified insulation, heat transfer between the unit exterior and ambient air, heat transfer between the two conditioned air streams, and condensation on surfaces. Insulation shall conform to ASTM C 1071. Paint

and finishes shall comply with the requirements specified in paragraph "Factory Coating".

2.12.9.1 Indoor Cabinet

Indoor cabinets shall be suitable for the specified indoor service and enclose all unit components.

2.12.9.2 Outdoor Cabinet

Outdoor cabinets shall be suitable for outdoor service with a weathertight, insulated and corrosion-protected structure. Cabinets constructed exclusively for indoor service which have been modified for outdoor service are not acceptable.

2.12.10 Humidifier

2.12.10.1 Steam Spray Type

Steam spray humidifiers shall inject steam directly into the [surrounding air] [or] [air stream]. [Single grid humidifiers shall consist of a single copper distribution grid with pipe connection on one end and cap on the other end. Automatic steam control valves and condenser traps shall be field-installed.] [Enclosed grid shall be housed in a copper enclosure with a built-in condensate drain connection. Exposed grid shall be wick wrapped.] [Package type steam spray humidifiers shall be equipped to trap out and to evaporate condensate and to supply dry steam to a single distribution grid. Grid shall be steam jacketed and condensate drained. Unit shall trap excess condensate to return system. Package type steam spray humidifiers shall have modulating electric, electronic, or pneumatic steam control valve, as indicated.] Steam spray humidifiers shall be rated for humidifying capacity in pounds of steam per hour and at steam pressure as indicated.

2.12.10.2 Steam-Diffuser Type

Diffuser units shall be of a design that will separate any condensate from steam supply and provide positive drain of condensate to waste and supply dry steam only to air stream. Humidifiers may be installed on single or multiple units. Materials shall be [noncorrosive materials] [Type 300 stainless steel].

2.13 PUMPS

****

NOTE: Indicate on the drawings pump capacity, efficiencies, motor sizes, and impeller types. Typical impeller types include the double-suction horizontal split-case type, end-suction vertical split-case type, close-coupled end-suction type, close-coupled in-line type.

****

Pumps shall be the electrically driven, non-overloading, centrifugal type

which conform to HI 1.1-1.5. Pump capacity, efficiency, motor size, and impeller type shall be as indicated on the drawings. Pumps shall be selected at or near peak efficiency. Pump curve shall rise continuously from maximum capacity to shutoff. Shutoff head shall be approximately 20 percent greater than design head. Pump motor shall be totally enclosed and have sufficient wattage (horsepower) horsepower for the service required. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in the cover.

2.13.1 Construction

Shaft seal shall be mechanical-seal or stuffing-box type. Impeller shall be statically and dynamically balanced. Each pump casing shall be designed to withstand the discharge head specified plus the static head on system plus 50 percent of the total, but not less than 862 kPa (125 psi). 125 psi. Pump casing and bearing housing shall be close grained cast iron. High points in the casing shall be provided with manual air vents; low points shall be provided with drain plugs. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Shaft shall be carbon or alloy steel, turned and ground. Bearings shall be ball-bearings, roller-bearings, or oil-lubricated bronze-sleeve type bearings, and be efficiently sealed or isolated to prevent loss of oil or entrance of dirt or water. Pump motors, unless otherwise indicated, shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures. [Pump and motor shall be mounted on a common cast iron base having lipped edges and tapped drainage openings or structural steel base with lipped edges or drain pan and tapped drainage openings.] [Pump shall be provided with shaft coupling guard.] [Close coupled pumps shall be provided with drip pockets and tapped openings.] Pump motor shall have the required capacity to prevent overloading with pump operating at any point on its characteristic curve. Pump speed shall not exceed 3,600 rpm, except where the pump head is less than 180 kPa (60 feet of water), 60 feet of water, the pump speed shall not exceed 1,750 rpm. Pump shall be accessible for servicing without disturbing piping connections.

2.13.2 Mechanical Shaft Seals

Seals shall be single, inside mounted, end-face-elastomer bellows type with stainless steel spring, brass or stainless steel seal head, carbon rotating face, and tungsten carbide sealing face. Glands shall be bronze and of the water-flush design to provide lubrication flush across the face of the seal. Bypass line from pump discharge to flush connection in gland shall be provided, with filter or cyclone separator in line.

2.13.3 Stuffing-Box Type Seals

Seals shall be single unit construction separate from the casing, secured against rotation. Stuffing box shall include minimum 5 rows of square, graphite braided asbestos packing and a bronze split-lantern ring. Packing gland shall be bronze interlocking split type.

2.14 COOLING TOWER

****

NOTE: Locate the tower in accordance with NFPA 214, and determine the extent and type of fire protection required for all size towers using the factors indicated in NFPA 214. Concrete structured towers are selected for their longevity over conventional type, but are considerably more expensive and should be used only if cost effective. PVC fill for concrete towers is considerably less expensive and should be specified unless tile fill can be justified. When project requirements limit the use of wood construction in cooling towers, all references to wood construction will be removed.

****

2.14.1 Fire Safety

Towers shall conform to NFPA 214. Fire hazard rating for plastic impregnated materials shall not exceed 25. Plastics shall not drip or run during combustion. Determine ratings by ASTM E 84 or NFPA 255.

2.14.2 Lumber

Lumber required for cooling tower construction shall be as defined by the following type woods:

2.14.2.1 Douglas Fir

CTI Std-114, WWPA Grading Rules, Grade B and better, Industrial Clear. Douglas fir shall have a preservative treatment in accordance with CTI Std-112.

2.14.2.2 Plywood

CTI Std-134, Exterior Grade, type and thickness as specified for the application.

2.14.2.3 Pressure Treated Lumber

Pressure treated lumber shall be in accordance with CTI Std-112. Wood exposed as the result of notching, cutting, or drilling shall be saturated with the preservative.

2.14.2.4 Redwood

CTI Std-103, CRA RIS-01-SS California Redwood, clear of all hearts.

2.14.3 Fiberglass Reinforced Plastic (FRP)

FRP components shall be inert, corrosion resistant, and fire-retardant with a thickness of 3.66 kg/square meter (12 ounces per square foot). 12 ounces per square foot. FRP components shall contain an ultraviolet (UV) ray inhibitor as per CTI Std-137, Grade 1 or 3.

2.14.4 Zinc-Coated Steel

Components fabricated of zinc-coated steel shall be not lighter than 16 gauge steel, protected against corrosion by a zinc coating. The zinc coating shall conform to ASTM A 153/A 153M and ASTM A 123/A 123M, as applicable and have an extra heavy coating of not less than 0.76 kg per square meter (2-1/2 ounces per square foot) 2-1/2 ounces per square foot of surface. Galvanized surfaces damaged due to welding shall be coated with zinc rich coating conforming to ASTM D 520, Type I.

2.14.5 Polyvinyl Chloride (PVC) Formed Sheets

ASTM D 1784, Type I, Grade 1 with a flame spread rating of 15 or less per ASTM E 84.

2.14.6 Hardware

Bolts shall be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt shall be provided with neoprene and cadmium-plated steel washers under the heads. Nails shall be silicon bronze, commercial bronze, or stainless steel. Hardware shall meet the salt-spray fog test as defined by ASTM B 117.

2.14.7 Noise Control

****

NOTE: Where cooling towers are in the proximity of residential, administrative, medical, or similar inhabited facility, the maximum acceptable noise limits for such applications should be determined in NC level or dBA, and coordinated with local code requirements and the cooling tower manufacturer. The noise level criteria should be scheduled on the drawing.

****

Sound power levels (in decibels with a reference pressure of 0.0002 microbar) of the cooling tower shall not exceed the maximum permitted decibel levels for the designated octave band as set forth in the following tables. Base the sound power level data for the cooling tower on tests conducted in accordance with ANSI S1.13.

Octave Band (in Hz)	63	125	250	500	1000	2000	4000	8000
Sound Power Level in dB	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]	[_____]

2.14.8 Conventional Type Tower

a. Factory-Assembled: Each tower shall be the induced mechanical draft, [crossflow] [or] [counterflow], factory fabricated, factory-assembled type.

b. Field-Assembled: Each tower shall be the induced mechanical draft, [crossflow] [or] [counterflow], factory fabricated, field-assembled type. Notching structural members may be permissible only if the members are increased proportionately in size to provide equivalent strength. Framework design for wood towers shall conform to requirements of CTI Std-103 for redwood construction and CTI Std-114 for Douglas-fir construction.

2.14.8.1 Casing

****
NOTE: Delete the last two sentence if inapplicable.
****

Casing shall be constructed of [zinc-coated steel] [lumber] [Type 304 stainless steel] [FRP]. Towers shall be designed and constructed to withstand a wind pressure of not less than 1.4 KPa (30 pound-force per square foot (psf)) 30 pound-force per square foot (psf) on external surfaces. Fan decks shall be designed to withstand a live load of not less than [1.9] [2.9] kPa ([40] [60] psf) [40] [60] psf in addition to the concentrated or distributed loads of equipment mounted on the fan decks. A 15-percent increased loading shall be included for ice or snow load. Air inlet and discharge terminations shall have flanged or lipped projections for connecting ductwork.

2.14.8.2 Cold-Water Basin

Basin shall be completely watertight and constructed of [36 mm (1-1/2 inch) 1-1/2 inch tongue and groove lumber] [concrete in accordance with Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE, 1.38 MPa (2,500 psi) 2,500 psi Class and reinforced as indicated.] [Type 304 stainless steel] [FRP]. Basin shall be constructed and installed to ensure that air will not be entrained in outlets when operating and no water will overflow on shutdown. Each individual sump shall be provided with an individual outlet. Each outlet shall be provided with a 1/2 inch mesh, zinc-coated steel wire securely mounted to prevent trash from entering the outlet. Each basin shall be provided with overflow and valved drain connections. Each basin shall be provided with a float-controlled, makeup water valve as indicated. The makeup water shall discharge not less than 50 mm 2 inches or 2 pipe diameters, whichever is greater, above the top of the basin.

2.14.8.3 Hot-Water Distribution

Design water distribution systems for each cell of each tower so that a water flow of 140 percent of specified water flow will not cause overflowing or splashing. Water distribution systems shall be accessible and permit flexibility of operation. Provide removable covers of same material and thickness as casing for entire water distribution basin. Support covers by basin sides with top of cover flush with top of basin. Provide separate regulation and stop valves for complete balancing and complete shutoff from each cell. Systems shall be self-draining and nonclogging. The water distribution system shall be either one of the following types.

a. Open Basins: Basins shall be provided with a splash box or baffles to minimize splashing of incoming hot water, holes that evenly distribute the water over the entire decking area, and a basin cover. Holes used in a water basin shall be provided with ceramic or plastic orifice inserts.

b. Spray Nozzles: Spray nozzles shall be cleanable; stainless steel, bronze, or high-impact plastic, nonclogging, removable; and, spaced for even distribution.

2.14.8.4 Fill Material

The fill shall be the following materials as specified. PVC formed sheets arranged in a honeycomb or waveform configuration; zinc-coated steel treated Douglas-fir; or treated hemlock and treated redwood. Zinc-coated steel shall have a minimum of 765 g per square meter 2.5 ounces per square foot of surface. Fill material shall be free to expand or contract without warping. PVC fill shall not be provided when inlet temperatures exceed 52 degrees C (125 degrees F). 125 degrees F. No plasticized wood cellulose shall be provided for fill material. Fill shall be removable or otherwise made accessible for cleaning. Provide space supports as required to prevent sagging and misalignment, and provide for an even mixing of air and water.

2.14.8.5 Drift Eliminator

Provide in tower outlet to limit drift loss to not over 0.02 percent of specified water flow. Eliminators shall be constructed of not less than 10 mm (3/8 inch) 3/8 inch lumber or polyvinyl chloride (PVC).

2.14.8.6 Fan Cylinder

Each fan shall be mounted in a fan cylinder to elevate the fan discharge air. Total extension height shall not exceed the fan diameter. Fan cylinders shall be constructed of zinc-coated steel, lumber, Type 304 stainless steel, or FRP and be compatible with the entire tower construction. Each fan cylinder shall be provided with a zinc-coated steel 2.75 mm (12 gauge) 12 gauge wire mesh securely mounted to the top of the cylinder in accordance with manufacturer's recommendations.

2.14.8.7 Framework and Equipment Supports

Framework and equipment supports shall be zinc-coated steel [,Type 304 stainless steel,] [FRP,] or lumber. Materials provided for framework, casings and equipment supports shall be compatible.

2.14.8.8 Structural Supports

Structural supports shall be provided in accordance with the recommendations of the manufacturer of the tower unless otherwise indicated.

2.14.8.9 Foundations

****

NOTE: For the design of a tower foundation, indicate the location, the size, the reinforcement requirements, etc., necessary for a cooling tower available from 3 commonly known manufacturers. For small retrofit type jobs the designer may choose to show the general layout of the foundation and rely on the Contractor to design and construct the foundation based on the cooling tower to be provide. Delete the last 2 sentences of the paragraph if the foundation is not to be designed by the Contractor.

****

Cooling tower foundations shall meet the requirements of the cooling tower manufacturer and be as indicated. Foundation design shall be based on the load conditions and soil bearing value indicated. Foundation calculations shall be submitted with the equipment drawings.

2.14.9 Concrete Structured Type

Each tower shall be the induced mechanical draft, counterflow, factory fabricated, field-assembled type.

2.14.9.1 Casing

The wall sections shall be constructed of air entrained concrete mix. Concrete shall conform to Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Exposed concrete shall be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete shall not be permitted. Any cold-pour joints in vertical walls shall have a continuous water-stop stripping of molded polyvinyl plastic (150 mm 6 inch dumbbell).

2.14.9.2 Cold-Water Basin

Basin floor slab shall be a continuous pour of high density air entrained concrete. The mix shall be of a strength to test a minimum of 27.6 MPa (4,000 psi) 4,000 psi (28 days) compressive. Air entrained cement, conforming to Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE, shall be used throughout the tower structure. Structure shall contain the reinforcing steel as detailed. Standard curing measures shall be carried out to protect the concrete while "green". Exposed concrete shall be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete shall not be permitted. A continuous water-stop stripping of molded polyvinyl plastic (150 mm 6 inch dumbbell) shall be located on the centerline position of the basin wall section/floor slab intersection, and at all other cold pour joints. Basin wall sections shall be made in a second continuous pour, contain the necessary reinforcing steel as submitted by the manufacturer and approved, and be arranged to interlock with the water-stop seal in the floor slab, forming a completely waterproof basin.

2.14.9.3 Hot-Water Distribution

Distribution system for each cell shall consist of a centrally located header complete with junction boxes, side laterals, fittings, and nozzles.

Piping shall be either cast iron, ductile iron, threaded-glass-fiber reinforced epoxy pipe, polypropylene, PVC or Schedule 80 black steel. Junction boxes shall be cast iron and nozzles shall be brass, stainless steel or plastic. Distribution piping including spray nozzles, pipe, fittings, and junction boxes shall be provided complete to flange face located at a point 150 mm 6 inches below top of fill support beam. Provisions shall be provided for balancing of water flow between cells or spray trees.

2.14.9.4 Fill Material

Fill material shall be [tile of multicell design, set without mortar] [or] [PVC formed sheets], in a pattern, and of sufficient height to meet the performance specifications. [Tile fill shall be vitreous, with a low water absorption that will pass a freeze-thaw test conducted in accordance with ASTM C 67. Tile fill shall have a minimum crushing strength of 13.8 MPa (2,000 psi) 2,000 psi over the gross area of the tile when the load is applied parallel to the cells as tested in accordance with ASTM C 67. Cast iron tee section lintels supporting the tile fill shall conform to ASTM A 48, ASTM A 48M, Class 25, 3.2 mm 1/8 inch additional thickness for corrosion. Lintels shall be designed with a safety factor of 2 minimum.] [PVC fill shall be manufactured from minimum nominal [0.5] [0.38] ([20] [15] mil) [20] [15] mil sheets. PVC fill shall be supported by the tower structure using corrosion resistant members. PVC sheets shall be arranged in a honeycomb or waveform configuration and shall have a flame spread rating of 25 or less when tested in accordance with ASTM E 84. Fill material shall be free to expand or contract without warping or cracking.]

2.14.9.5 Drift Eliminators

Eliminators shall be of the multi-pass zigzag type, assembled into sections making a strong, stable unit. Provide in tower outlet to limit drift loss to not over 0.005 percent of the water flow. These sections shall be supported on PVC or FRP tee sections. Tee sections shall be suspended with 6.35 mm (1/4 inch) 1/4 inch brass rods connected to stainless steel clips embedded in the bottom side of the roof deck at the time of casting. Stainless steel clips shall be supplied by cooling tower manufacturer for installation by Contractor at time of roof deck pour. Eliminators may be supported by brass or stainless steel suspension rods from the fan deck or supported directly on concrete beams. Eliminators may be either PVC extruded sections or wave formed sheets of PVC resin conforming to ASTM D 1784 Type I, Grade 2. Eliminators and supporting framework shall have flame spread rating of 25 or less when tested in accordance with ASTM E 84.

2.14.9.6 Fan Decks and Stacks

Construct fan decks of precast, reinforced lightweight concrete, in multiple sections, forming a complete, vibration-free base for mounting fan, speed reducer, drive shaft, motor, and fan stacks. Construct fan stacks of precast, reinforced lightweight concrete in multiple sections, constrained with bands of zinc-coated steel conforming to ASTM A 123/A 123M, not less than 3 by 75 mm (1/8 by 3 in.), 1/8 by 3 in., and bolted to form a compressive load on stack perimeter. Secure stack in place on fan deck with Class A mortar.

2.14.10 Louvers

Air inlets for each cooling tower shall be provided with individually removable louvers arranged to prevent the escape of water. Louvers shall be zinc-coated steel, [Type 304 stainless steel,] [FRP,] or lumber. Materials provided for casings and louvers shall be compatible; one material shall not produce stains upon the other. Louvers constructed of lumber shall be of a thickness to withstand alternate wetting and drying without cracking or splitting. Air intakes shall be provided with 25 mm 1 inch zinc-coated steel mesh.

2.14.11 Fans

****

NOTE: When the density of the ambient air to be handled by the fans differs substantially from the density of the standard air value of 1.2 kg per cubic meter (0.075 pound per cubic foot) at 21.1 degrees C (70 degrees F) and 101.325 kPa (29.92 inches mercury), the density of the air and/or the elevation above mean sea level will be stated.

****

Fans shall be the [centrifugal] [or] [adjustable-pitch propeller] type, constructed of zinc-coated steel, Type 304 stainless steel, aluminum or an aluminum alloy, or FRP. Propeller type shall have a maximum tip speed of 55 m (11,000 fpm. 11,000 fpm. Fan blade assembly shall be both statically and dynamically balanced after assembly of the cooling tower. Fan hub shall be constructed of [zinc-coated steel] [stainless steel] [cast aluminum] with adequate surface protection against corrosion. Complete fan assembly (fan and mounting) shall be designed to give maximum fan efficiency and long life when handling saturated air at high velocities.

2.14.12 Speed Reducer Gears and Drive Shaft

****

NOTE: Double reduction gear reducer should be considered where low noise requirement is a factor.

****

Speed reducer gears shall be rated in accordance with CTI Std-111. Gear reducers shall be of the [spiral bevel, single reduction] [spiral or helical, double reduction] type. Reducer shall be mounted in accordance with manufacturer's recommendations. Each reducer shall be provided with an oil level cutoff switch interlocked to the fan motor. Each reducer shall be provided with an oil level sight glass, fill, drain, and vent lines located in a readily accessible position. Drive shafts shall be the full floating type with flexible couplings at both ends and have a service factor of 1.0 or greater. Drive shafts shall be of stainless steel, fitted each end with flexible couplings (stainless steel plate type). Each drive shaft shall be provided with a galvanized steel guard, to prevent damage to surrounding equipment in case of shaft failure. Provision shall be made for lubrication of all bearings. Bearings shall be accessible to the

extent that each bearing can be lubricated without dismantling fan.

2.14.13 Fan Motor

****
NOTE: Delete the last sentence if inapplicable.
****

Each motor shall be a [single speed] [two speed], totally enclosed, insulation Class B, NEMA Design B, continuous-rated, and conforming to NEMA MG 1. Fan motors shall have [open] [dripproof] [totally enclosed] [explosion proof] enclosures and be located outside the discharge airstream. Motors shall be mounted according to manufacturer's recommendations. Two-speed motors shall have a single winding with variable torque characteristics.

2.14.14 Stairways and Ladders

Provide stairs, 60-degree ship ladders or straight-rung ladders of standard design, starting at [ground] [roof] level and extending as high as required to gain access to fan decks and water distribution systems. Stairways and ladders, shall be hot-dip, zinc-coated steel. Ladders higher than 3.66 mm (12 feet) 12 feet shall have a safety cage.

2.14.15 Handrailings

Steel handrailings shall be not less than 1067 mm (42 inches) 42 inches high around the exterior of each working surface that is 3.66 m (12 feet) 12 feet or more above the ground, roof, or other supporting construction. Railings shall be not smaller than 32 mm (1-1/4 inch) 1-1/4 inch zinc-coated steel pipe with standard zinc-coated steel railing.

2.14.16 Access Doors

Each tower shall be provided with access doors at grade level to provide entry to the interior for service maintenance without removal of the fill. Doors shall be provided on each endwall of each cooling tower cell. Frame and brace access doors to prevent damage when opening and closing. Locate doors adjacent to float controls.

2.14.17 Acceptable Manufacturers of Cooling Towers

Baltimore Aircoil Co., Model [_____].
Evapco, Inc., Model [_____].
Marley Cooling Tower Co., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.15 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing hexavalent chromium (Cr) is prohibited.

2.15.1 Water Analysis

****
NOTE: A water analysis may be available from the user. If an analysis is not available, an analysis will be performed during the design, and appropriate data will be entered.
****

Conditions of make-up water to be supplied to the condenser and chilled water systems were reported in accordance with ASTM D 596 and are as follows:

Date of Sample	[_____]	
Temperature	[_____]	degrees C F
Silica (SiO2)	[_____]	ppm (mg/1)
Insoluble	[_____]	ppm (mg/1)
Iron and Aluminum Oxides	[_____]	ppm (mg/1)
Calcium (Ca)	[_____]	ppm (mg/1)
Magnesium (Mg)	[_____]	ppm (mg/1)
Sodium and Potassium (Na and K)	[_____]	ppm (mg/1)
Carbonate (HCO3)	[_____]	ppm (mg/1)
Sulfate (SO4)	[_____]	ppm (mg/1)
Chloride (Cl)	[_____]	ppm (mg/1)
Nitrate (NO3)	[_____]	ppm (mg/1)
Turbidity	[_____]	unit
pH	[_____]	
Residual Chlorine	[_____]	ppm (mg/1)
Total Alkalinity	[_____]	epm (meq/1)
Non-Carbonate Hardness	[_____]	epm (meq/1)
Total Hardness	[_____]	epm (meq/1)
Dissolved Solids	[_____]	ppm (mg/1)
Fluorine	[_____]	ppm (mg/1)
Conductivity	[_____]	micrmho/cm

2.15.2 Chilled and Condenser Water

Water to be used in the chilled and condenser water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.15.3 Glycol Solution

****
NOTE: Delete this paragraph if a dry cooler is not specified. When a glycol system is used, the size of the HVAC systems should be corrected due to changes in specific heat and viscosity. ASHRAE's "HVAC Systems and Equipment Handbook" should be consulted for the appropriate calculation procedures. Ethylene glycol should be used for HVAC

systems however, if the heat transfer media has the possibility of mixing with a potable water system, propylene glycol should be used. The required concentration should be entered based upon the anticipated ambient or operating temperature.

****

A [_____] percent concentration by volume of industrial grade [ethylene] [propylene] glycol shall be provided for the system. The glycol shall be tested in accordance with ASTM D 1384 with less than 0.013 mm (0.5 mils) 0.5 mils penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicate based inhibitors shall not be used. The solution shall be compatible with pump seals, other elements of the system, and all water treatment chemicals used within the system.

2.15.4 Water Treatment Services

****

NOTE: The services of a water treatment company to treat a chilled water system should only be required if the makeup water available is of very poor quality.

****

The services of a company regularly engaged in the treatment of [condenser] [condenser and chilled] water systems shall be used to determine the correct chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company shall maintain the chemical treatment and provide all chemicals required for the [condenser] [condenser and chilled] water systems for a period of one year from the date of occupancy. The chemical treatment and services provided over the one year period shall meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Acid treatment and proprietary chemicals shall not be used.

2.15.5 Chilled Water System

****

NOTE: For dual temperature systems (chilled and heated water), coordinate the compatibility of the separate water treatment systems.

****

A shot feeder shall be provided on the chilled water piping as indicated. Size and capacity of feeder shall be based upon local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.15.6 Condenser Water

****

NOTE: Cooling towers with a capacity of greater than 176 kW (50 tons) will be provided with

automatic chemical feed and blow down systems. Smaller towers will be provided with continuously activated systems. Indicate the location of the entire water treatment system. Delete all the information under this paragraph if a cooling tower is not used in the system.

****

The water treatment system shall be capable of [automatically] [continuously] feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. [Automatic chemical feed systems shall automatically feed chemicals into the condenser water based on varying system conditions.] [Continuously chemical feed systems shall continuously feed chemicals into the condenser water at a constant rate. The system shall be initially set manually based on the water analysis of the make-up water.]

2.15.6.1 Chemical Feed Pump

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.15.6.2 Tanks

Two chemical tanks shall be provided. The tanks shall be constructed of [high density polyethylene] [stainless steel] with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided for each tank.

2.15.6.3 Injection Assembly

An injection assembly shall be provided at each chemical injection point along the condenser water piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the condenser water piping. Each assembly shall include a shut-off valve and check valve at the point of entrance into the condenser water line.

2.15.6.4 Water Meter

Water meters shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the make-up water line, as indicated.

2.15.6.5 Timers

Timers shall be of the automatic reset, adjustable type, and electrically operated. The timers shall be suitable for a 120 volt current. The timers shall be located within the water treatment control panel.

2.15.6.6 Water Treatment Control Panel

****

NOTE: The MAN-OFF-AUTO switch should be deleted for continuously fed systems. In areas where a panel could come in contact with the water treatment chemical, choose the stainless steel construction.

****

The control panel shall be a NEMA 12 enclosure suitable for surface mounting. The panel shall be constructed of [stainless steel] [steel] with a hinged door and lock. The panel shall contain a laminated plastic nameplate identifying each of the following functions:

(1) Main power switch and indicating light;
(2) MAN-OFF-AUTO selector switch;
(3) Indicating lamp for bleed-off valve;
(4) Indicating lamp for each chemical feed pump;
(5) Set point reading for each timer;

2.15.6.7 Chemical Piping

The piping and fittings shall be constructed of [schedule 80 PVC] [stainless steel] suitable for the water treatment chemicals.

2.15.6.8 Sequence of Operation

****

NOTE: Choose the first set of brackets for automatic chemical feed systems. Choose the second set of brackets for continuous chemical feed systems.

****

[The chemicals shall be added based upon sensing the make-up water flow rate and activating appropriate timers. A separate timer shall be provided for each chemical. The blow down shall be controlled based upon the make-up water flow rate and a separate timer.] [The system shall contain an adjustable valve for continuous blow down. The flow rate from the appropriate chemical tanks shall be manually set at the metering pump for continuous chemical feed.] The injection of the chemical required for biological control shall be controlled by a timer which can be manually set for proper chemical feed. All timer set points, blow down rates, and chemical pump flow rates shall be determined and set by the water treatment company.

2.15.6.9 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.15.6.10 Bleed Line

****

NOTE: Delete the following paragraph on bleed lines if an automatic chemical system is chosen.

****

A bleed line with a flow valve of the needle-valve type sized for the flow requirement or fixed orifice shall be provided in the pump return to the tower. The bleed line shall be extended to the nearest drain for continuous discharge.

2.16 EXPANSION TANK

Tank shall be welded steel, constructed, tested and stamped in accordance with ASME BPV VIII Div 1 for a working pressure of [825] [_____] kPa ([125] [_____] psig) [125] [_____] psig and precharged to the minimum operating pressure. Tank shall have a replaceable diaphragm and be the captive air type. Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with an air charging valve. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.16.1 Acceptable Manufacturers of Expansion Tanks

Armstrong Pumps, Inc., Model [_____].
Bell & Gossett Corp., Model [_____].
Taco, Inc., Model [_____].
Or an approved equal in accordance with section 00700, Materials and Workmanship.

2.17 AIR SEPARATOR TANK

External air separation tank shall be steel, constructed, tested, and stamped in accordance with ASME BPV VIII Div 1 for a working pressure of [825] [_____] kPa ([125] [_____] psi). [125] [_____] psi.

2.18 PURGE SYSTEM

****

NOTE: Refrigeration systems which operate below atmospheric pressure (i.e., R-123 machines) will require a refrigerant purge piping system. Indicate the routing of purge piping on the drawings. Require the Contractor to delete the piping if a purge system is not required for the type of refrigeration system that is to be provided. Indicate that it will be the contractor's responsible to size the piping based upon the recommendations of the refrigeration system's manufacturer. Purge discharge piping may be connected to the pressure-relief piping on the

equipment side of the piping's vibration isolators.

****

Refrigeration systems which operate at pressures below atmospheric pressure shall be provided with a purge system. Purge systems shall automatically remove air, water vapor, and non-condensible gases from the system's refrigerant. Purge systems shall condense, separate, and return all refrigerant back to the system. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into the system.

2.19 REFRIGERANT LEAK DETECTOR

****

NOTE: Refrigerant leak detectors will be provided as required by the "System Application Requirements" in ASHRAE 15.

When a detector is required, the location will be indicated on the drawings. Detectors are best located between the refrigeration system and the room exhaust. Sampling points from a detector will be located a maximum of 18 inches above the finished floor since all commonly-used refrigerants are heavier than air

As a rule of thumb, the distance between any refrigeration system and a refrigerant sampling point shouldn't exceed 50 feet. In order to meet the recommended 50 foot distance, a mechanical room can be provided with either multiple detectors each with single sampling points or with one detector that has the capability of monitoring at multiple sampling points. If multiple sampling points are required, enter the number in the appropriate blank below.

Per ASHRAE 15, when a detector senses refrigerant it must activate an alarm and initiate the room ventilation system. In regards to alarms, as a minimum indicate that the detector will energize a light on or near the detector as well as a second light installed on the outside wall next to the mechanical room entrance. The exterior light will be provided with a sign that warns personnel entering the mechanical room of a refrigerant release and that a SCBA is required to enter. If applicable to the installation, include an audible alarm on the exterior of the mechanical room.

Include the electrical design for the alarm system on the drawings.

As an additional item, ASHRAE 15 states that open-flame devices (i.e., boilers, etc.) cannot be installed in the same area as a refrigeration system, unless either combustion air for the open-flame device is ducted straight from outside to the device; or the alarm relay from the detector is used to automatically shutdown the combustion process in the event of refrigerant leakage. Indicate all applicable alarm controls on the drawings.

Delete the information in the last bracketed sentences if an EMCS is not applicable to the design.

****

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include [a single sampling point] [_____ sampling points] installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant. Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant in use. The detector's relay shall be capable of initiating corresponding alarms and ventilation system as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. [Detector shall be compatible with the facility's energy management and control system (EMCS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.]

2.20 REFRIGERANT RELIEF VALVE/RUPTURE DISC ASSEMBLY

****

NOTE: ASHRAE 15 requires refrigeration systems to be protected with a pressure-relief device that will safely relieve pressure due to fire or other abnormal conditions. A relief valve/rupture disc assembly is the optimum solution. The rupture disc will provide visual indication of a release while also providing immediate shutoff once a safe pressure is achieved.

Designer will indicate on the drawings the location of each new relief valve/rupture disc assembly s well as the routing and size of corresponding

pressure-relief piping. The routing and size of new pressure-relief piping will be per ASHRAE 15.
****

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPV IX and ASHRAE 15. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.21 REFRIGERANT SIGNS

refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 12 mm 0.5 inches in height.

2.21.1 Installation Identification

Each new refrigeration system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name
b. Refrigerant number and amount of refrigerant.
c. The lubricant identity and amount.
d. Field test pressure applied.

2.21.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg 110 lb of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow [, the ventilation system,] and the refrigerant compressor.
b. Pressure limiting device.

2.22 INSULATION

2.22.1 Field Installed Insulation

Field installed insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.22.2 Factory Installed Insulation

Factory applied insulation shall be as specified for the equipment to be insulated except that refrigerant suction lines shall be insulated with unicellular plastic foam. Insulation shall comply with the fire hazard rating specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.23 HEAT RECOVERY DEVICES

2.23.1 Hot Air Reclaim

Unit shall be a heat recovery, factory-fabricated, draw-through, central station type air conditioner in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

2.23.2 Hot Water Reclaim

****

NOTE: Indicate the size of the exchanger either as a percent of the total rated condenser load or as a percent of the superheated portion of the total rated condenser load. The refrigerant compressor head pressure control and the circulating pump can be deleted if inapplicable.

****

Unit shall be a double-wall, tube-within-tube heat exchanger type, complete with thermostatic control. Unit shall be constructed and refrigerant pressure/temperature rated in accordance with ASHRAE 15. Heat exchanger coil shall consist of an external refrigerant containing carbon steel tube and an internal, double-wall-in-metallic contact, convoluted, potable water containing copper tube. Cabinet shall be fabricated of zinc-protected steel and be internally insulated in coil space. The recovery device shall be provided with a refrigerant compressor head pressure control and a interlocked, potable water circulating pump. Pump and motor assembly shall be close-coupled, manufacturer's standard type with indicated head and capacity characteristics, and with brass, bronze, copper or stainless steel wetted parts. Pump shall be mounted [remotely] [integral] to the exchanger and be rated for [115] [208] [230] volt ac power supply.

2.24 TEMPERATURE CONTROLS

****

NOTE: This paragraph should only be included for packaged and self-contained unitary systems requiring controls (i.e. thermostats, duct modulation, SLDC, etc.) not covered by this specifications. In projects where this section of the specification is intended to produce control equipment for existing air-side systems, this paragraph will be rewritten to secure controls to match existing controls and to properly integrate the specified controls into the existing temperature control system.

A sequence of control, a schematic of controls, and a ladder diagram should be included on the drawings for each cooling tower fan, chilled water pump, condenser water pump, etc. in order to define the overall system operation.

****

Temperature controls shall be [in accordance with Section 15950HEATING, VENTILATING AND AIR CONDITIONING HVAC CONTROL SYSTEMS] [fully coordinated with and integrated into the existing air-conditioning system].

2.25 DUCTWORK COMPONENTS

****

NOTE: The appropriate pressure classification from SMACNA TAB HVAC Sys, including points of changes in pressure classification, will be noted on the drawings. Indicate pitch of ductwork, low spots in ductwork, and means of disposing of condensate, where applicable.

The use of flexible duct should be limited due to the inordinate pressure drop and corresponding fan energy consumption that it causes. The extent of flexible duct will be shown on the drawings. The designer should also ensure that the restrictions in these standards pertaining to the use of non-metallic materials in air distribution plenums are followed.

The flammability and combustibility of non-metallic duct materials is controlled by NFPA 90A, 90B, and 91. The extent of non-metallic duct that can be used should be shown on the drawings when these standards limit its use.

****

2.25.1 Metal Ductwork

Every aspect of metal ductwork construction, including fittings and components, shall comply with SMACNA TAB HVAC Sys unless otherwise specified. Elbows shall be radius type with a centerline radius of 1-1/2 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure Class 125, 250, 500 Pa (1/2, 1, and 2 inch w.g.) 1/2, 1, and 2 inch w.g. ductwork shall meet the requirements of Seal Class C. Class 750 through 2500 Pa (3 through 10 inch) 3 through 10 inch shall meet the requirements of Seal Class A. Sealants shall conform to fire hazard classification specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA TAB HVAC Sys. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be applied over the outside of the joint to at least 50 mm 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable.

2.25.1.1 Transitions

Diverging air flow transitions shall be made with each side pitched out a maximum of 15 degrees, for an included angle of 30 degrees. Transitions for converging air flow shall be made with each side pitched in a maximum of 30 degrees, for an included angle of 60 degrees, or shall be as indicated. Factory-fabricated reducing fittings for systems using round duct sections when formed to the shape of the ASME short flow nozzle, need not comply with the maximum angles specified.

2.25.1.2 Metallic Flexible Duct

Metallic type duct shall be single-ply [galvanized steel] [Type 316 stainless steel] [two-ply aluminum] [, self supporting to 2.4 m 8 foot spans]. Duct shall be of corrugated/interlocked, folded and knurled type seam construction, bendable without damage through 180 degrees with a throat radius equal to 1/2 duct diameter. Duct shall conform to UL 181 and shall be rated for positive or negative working pressure of 3.75 kPa (15 inches water gauge) 15 inches water gauge at 177 degrees C (350 degrees F) 350 degrees F when duct is aluminum, and 343 degrees C (650 degrees F) 650 degrees F when duct is galvanized steel or stainless steel.

2.25.1.3 Insulated Nonmetallic Flexible Duct Runouts

Flexible duct runouts shall be used only where indicated. Runouts shall not exceed 3 m 10 feet in length, shall be preinsulated, factory fabricated, and comply with NFPA 90A and UL 181. Either field or factory applied vapor barrier shall be provided. Where coil induction or high velocity units are supplied with vertical air inlets, a streamlined and vaned and mitered elbow transition piece shall be provided for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulation material surface shall not be exposed to the air stream.

2.25.1.4 General Service Duct Connectors

A flexible duct connector approximately 150 mm 6 inches in width shall be provided where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, the flexible material shall be secured by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, the flexible material locked to metal collars shall be installed using normal duct construction methods. The composite connector system shall comply with UL 214 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

2.25.2 Fibrous Glass Ductwork

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NOTE: Fibrous glass ducts will not be used in air-conditioning systems for medical facilities or in clean rooms with requirements equal to or exceeding Class 100. Refer to AFR 88-15 for use on

Air Force projects.
****

Fibrous glass ductwork may be provided in lieu of sheet metal ductwork except that fibrous glass ductwork will not be allowed in fan and equipment rooms, where subject to traffic or weather damage, for outside air intakes, for risers of more than two stories, in kitchen or fume exhaust ducts, to convey solids or corrosive gases, in concrete, for burial below grade, as casings or housings, or in systems used for life support systems. Fibrous glass ductwork, including all components, shall be fabricated in accordance with NAIMA AH115 where the velocity and the static pressure are within its scope. Where the velocity or static pressure exceeds these limits, the ductwork manufacturer shall certify that the ductwork is intended for the velocities and pressures to be encountered, and that the proposed installation meets all performance criteria specified herein for metal ductwork. Field or factory fabricated fibrous glass ductwork shall conform to UL 181, Class 1. [Duct wall penetrations,] transverse joints and longitudinal seams shall be sealed as instructed by the manufacturer by one of the methods prescribed by NAIMA AH115, where applicable, except that pressure sensitive tape shall not be used as a sealant. Items necessary for a complete installation shall be provided as specified for sheet metal duct systems.

2.25.3 Ductwork Insulation

Ductwork insulation and related materials shall conform to the requirements of Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.25.4 Ductwork Accessories

2.25.4.1 Duct Access Doors

****
NOTE: Provide duct access doors at regular intervals to facilitate the cleaning of duct systems for applications requiring clean air supplies, such as hospitals, laboratories, electronics servicing and similar activities.
****

Access doors shall be provided in ductwork where indicated and at all air flow measuring devices, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA TAB HVAC Sys. Access doors shall be provided upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 375 x 450 mm (15 x 18 inches), 15 x 18 inches, unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 600 x 600 mm (24 x 24 inches) 24 x 24 inches or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

2.25.4.2 Fire Dampers

****
NOTE: Indicate the location of each fire damper. Provide dampers in accordance with NFPA 90A. Three-hour rated fire dampers must be specifically identified.
****

Fire dampers shall be 1-1/2 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specific application and shall be installed according to their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire Resist Dir. Fire dampers shall be [curtain type with damper blades] [in the air stream] [out of the air stream] [or] [single blade type] [or] [multi-blade type]. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers shall be followed.

2.25.4.3 Splitters and Manual Balancing Dampers

****
NOTE: Indicate the location of all volume dampers. Diffuser and register volume dampers will not be used for balancing.
****

Splitters and manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portions of the building, operators shall be chromium plated with all exposed edges rounded. Splitters shall be operated by quadrant operators or 4.75 mm (3/16 inch) 3/16 inch rod brought through the side of the duct with locking setscrew and bushing. Two rods are required on splitters over 8 inches. Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gauges 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 300 mm. 12 inches. Access doors or panels shall be provided for all concealed damper operators and locking setscrews. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper

manufacturer. Volume dampers shall be provided where indicated.

2.25.4.4 Air Deflectors and Branch Connections

Air deflectors shall be provided at all duct mounted supply outlets, at all takeoff or extension collars to supply outlets, at all duct branch takeoff connections, and at all 90 degree elbows, as well as at all locations as indicated on the drawings or shown in the Sheet Metal and Air Contractors National Association manuals. Air deflectors, except those installed in 90 degree elbows, shall be provided with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Blade air deflectors, also called blade air extractors, shall be approved factory fabricated units consisting of equalizing grid and adjustable blade and lock. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein before. Fixed air deflectors, also called turning vanes, shall be provided in all 90 degree elbows. Turning vanes shall be designed as shown in the Sheet Metal and Air Condition Contractors National Association manuals.

2.25.5 Duct Sleeves, Framed Prepared Openings, Closure Collars

2.25.5.1 Duct Sleeves

Duct sleeves shall be provided for all round ducts 375 mm 15 inchesin diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 375 mm 15 inches in diameter and all square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor shall be responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 1.0 mm (20 gauge) 20 gauge galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, ASTM A 53, Schedule 20 shall be used. Sleeve shall provide 25 mm 1 inch clearance between the duct and the sleeve or 25 mm 1 inch clearance between the insulation and the sleeve for insulated ducts.

2.25.5.2 Framed Prepared Openings

Openings shall have 25 mm 1 inch clearance between the duct and the opening or 25 mm 1 inch clearance between the insulation and the opening for insulated ducts.

2.25.5.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 100 mm 4 inches wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 375 mm 15 inches in diameter or less shall be fabricated from 1.0 mm (20 gauge) 20 gauge galvanized steel. Collars for round ducts larger than 375 mm 15 inches and all square, and rectangular ducts shall be fabricated from 1.3 mm (18 gauge) 18 gauge galvanized steel. Collars shall be installed with fasteners on maximum 150 mm 6 inch centers, except that not less than 4 fasteners shall be used.

2.25.6 Sound Attenuation Equipment

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NOTE: Sound attenuators or acoustical duct liner will be used only where acoustical treatment is required and there are no other suitable alternatives. Acoustical duct liner will not be used in systems where the total pressure is above 4 inches water gauge in any portion of the air-conditioning system in medical facilities for Army construction. Refer to AFR 88-15 for use on Air Force projects.

Refer to TM 5-805-4, Noise and Vibration Control for Mechanical Equipment, for noise criteria. Sound power levels required should be included in the appropriate schedule on the drawings.

****

2.25.6.1 High Pressure Systems

Sound attenuators shall be provided on the discharge duct of each fan operating at a total pressure above 1 kPa (4 inches water gauge), 4 inches water gauge, and, when indicated, at the intake of each fan system. Sound attenuators shall be provided elsewhere as indicated. The sound attenuators shall be factory fabricated and shall be tested by an independent laboratory for sound and performance characteristics. Net sound reduction shall be as indicated. Maximum permissible pressure drop shall not exceed 157 Pa (0.63 inch water gauge). 0.63 inch water gauge. Traps shall be constructed to be airtight when operating under an internal static pressure of 2.5 kPa (10 inch water gauge). 10 inch water gauge. Air-side surface shall be capable of withstanding air velocity of 50 m/s (10,000 fpm). 10,000 fpm. The Contractor shall certify that the sound reduction values specified will be obtained after the equipment is installed in the system and coordinated with the sound information of the system fan to be provided. Sound absorbing material shall conform to ASTM C 1071, Type I or II. Sound absorbing material shall meet the fire hazard

rating requirements for insulation specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. A duct transition section shall be provided for connection to ductwork. Factory fabricated double-walled internally insulated spiral lock seam and round duct and fittings designed for high pressure air system may be provided in lieu of factory fabricated sound attenuators, and shall comply with all requirements specified for factory fabricated sound attenuators. The double-walled duct and fittings shall be constructed of an outer metal pressure shell of zinc-coated steel sheet, 25.4 mm (1 inch) 1 inch thick acoustical blanket insulation, and an internal perforated zinc-coated metal liner. Sufficient length of run shall be provided to obtain the noise reduction coefficient specified. The Contractor shall certify that the sound reduction value specified will be obtained within the length of duct run provided. The outer sheet metal of the double-walled duct shall have welded, or spiral lock, seams to prevent water vapor penetration. The outer sheet of the duct and fittings shall conform to the metal thickness of high pressure spiral and round ducts and fittings shown in SMACNA TAB HVAC Sys. The acoustical insulation shall have a thermal conductivity "k" of not more than 0.039 W/m-K (0.27 Btu/inch/square foot/hour/degree F) 0.27 Btu/inch/square foot/hour/degree F at 24 degrees C (75 degrees F) 75 degrees F mean temperature. The internal perforated zinc-coated metal liner shall be not less than 0.7 mm (24 gauge) 24 gauge with perforations not larger than 6.35 mm 1/4 inch in diameter providing a net open area not less than 10 percent of the surface.

2.25.6.2 Low Pressure Systems

Low pressure systems shall be defined as a system with a total pressure of 1 kPa (4 inches water gauge) 4 inches water gauge or lower. Sound attenuators shall be provided only where indicated, or in lieu of lined ducts. Factory fabricated sound attenuators shall be constructed of galvanized steel sheets. Outer casing shall be not less than 0.85 mm (22 gauge). 22 gauge. Acoustical fill shall be fibrous glass. Net sound reduction shall be as indicated. Values shall be obtained on a test unit not less than 600 mm 24 inches by 600 mm 24 inches outside dimensions made by a certified nationally recognized independent acoustical laboratory. Air flow capacity shall be as indicated or required. Pressure drop through the attenuator shall not exceed the value indicated, or shall not be in excess of 15 percent of the total external static pressure of the air handling system, whichever is less. Sound attenuators shall be acoustically tested with metal duct inlet and outlet sections while under the rated air flow conditions. Noise reduction data shall include the effects of flanking paths and vibration transmission. Sound attenuators shall be constructed to be airtight when operating at the internal static pressure indicated or specified for the duct system, but in no case less than 500 Pa (2 inch water gauge). 2 inch water gauge.

2.25.6.3 Acoustical Duct Liner

Acoustical duct lining shall be fibrous glass designed exclusively for lining ductwork and conform to the requirements of ASTM C 1071, Type I and II. Liner composition may be uniform density, graduated density, or dual density, as standard with the manufacturer. Lining shall be coated, not less than 25.4 mm (1 inch) 1 inch thick, nominal, and where applicable be of sufficient thickness to be thermally equivalent to the thickness of

insulation specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Duct sizes shown shall be increased to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, acoustically equivalent lengths of fibrous glass duct or factory fabricated double-walled internally insulated duct with perforated liner may be provided. Net insertion loss value, static pressure drop, and air flow velocity capacity data shall be certified by a nationally recognized independent acoustical laboratory.

2.25.7 Diffusers, Registers, and Grilles

****

NOTE: Coordinate with paragraph Sound Attenuation Equipment.

If diffusers or registers or grilles are not required, reference to the omitted items will be deleted. Specified performance characteristics peculiar to the omitted items will be deleted. If any one or two of the three types of units are omitted, the corresponding subparagraph will be deleted.

****

Units shall be factory-fabricated of steel, corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s (50 fpm) 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Performance shall be certified in accordance with ADC 1062:GRD. Inlets and outlets shall be sound rated and certified in accordance with ADC 1062:GRD. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Linear slot diffusers shall be provided with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 2 m 7 feet above the floor, they shall be protected by a grille or screen in accordance with NFPA 90A.

2.25.7.1 Diffusers

Diffuser types shall be as indicated. Ceiling mounted units shall be furnished with antismudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Elec Const Dir for the interchangeable use as cooled or heated air supply diffusers or return air units. Ceiling mounted units shall be installed with rims tight against ceiling. Sponge rubber gaskets shall be provided between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar

connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

2.25.7.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 150 mm 6 inches below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 150 mm 6 inches above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

2.25.8 Louvers

Louvers shall be furnished for installation in exterior walls which are directly connected by ductwork to air handling equipment. Louver blades shall be fabricated from anodized aluminum or galvanized steel sheets, and shall be provided with a frame of galvanized steel or aluminum structural shapes. Sheet metal thickness and fabrication shall conform to SMACNA TAB HVAC Sys. Blades shall be accurately fitted and secured to frames. Edges of louver blades shall be folded or beaded for rigidity and baffled to exclude driving rain. Louver shall be provided with bird screen. Louvers shall bear AMCA Certified Ratings Seal for air performance and water penetration ratings as described in AMCA 500.

2.26 CONDENSER WATER PIPING

2.26.1 Steel Pipe

Steel pipe shall conform to ASTM A 53, Schedule 40, Type E or S, Grades A or B. Type F pipe shall not be used.

2.26.2 Joints and Fittings, Steel Pipe

Joints and fittings shall be welded, flanged, threaded, or grooved as indicated. If not otherwise indicated, piping 25 mm (1 inch) 1 inch and smaller shall be threaded; piping larger than 25 mm (1 inch)1 inch and smaller than 80 mm (3 inches) 3 inches shall be either threaded, grooved, or welded; and piping 80 mm (3 inches) 3 inches and larger shall be grooved, welded, or flanged. Rigid grooved mechanical joints and fittings may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 110 degrees C (230 degrees F). 230 degrees F. Flexible grooved joints shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

2.26.2.1 Welded

Welded fittings shall conform to ASTM A 234/A 234M, and identified with the appropriate grade and marking symbol. Butt-welding fittings shall conform to ASME B16.9. Socket-welding and threaded fittings shall conform to ASME B16.11.

2.26.2.2 Flanged

Flanges shall conform to ASTM A 181/A 181M and ASME B16.5 Class 150. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1.6 mm (1/16 inch) 1/16 inch thickness, full face or self-centering flat ring type. This gaskets shall contain aramid fibers bonded with styrene butadine rubber (SBR) or nitrile butadine rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.5. Bolts shall be high or intermediate strength material conforming to ASTM A 193/A 193M.

2.26.2.3 Threaded

Threads shall conform to ASME B1.20.1. Pipe nipples shall conform to ASTM A 733, type and material to match adjacent piping. Unions shall conform to ASME B16.39, type as required to match adjacent piping.

2.26.2.4 Dielectric Unions and Flanges

Dielectric unions shall have the tensile strength and dimensional requirements specified. Unions shall have metal connections on both ends threaded to match adjacent piping. Metal parts of dielectric unions shall be separated with a nylon insulator to prevent current flow between dissimilar metals. Unions shall be suitable for the required operating pressures and temperatures. Dielectric flanges shall provide the same pressure ratings as standard flanges and provide complete electrical isolation.

2.26.2.5 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 862 kPa (125 psi) 125 psi service and shall the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A 47,ASTM A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12; or steel conforming ASTM A 106, Grade B or ASTM A 53. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D 2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 110 degrees C (230 degrees F) 230 degrees F or Grade No. M3BA610A15B44Z for circulating medium up to 93 degrees C (200 degrees F). 200 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A 183.

2.26.3 Copper Tube

Copper tubing for water service shall conform to ASTM B 88, ASTM B 88M, Type K or L.

2.26.4 Joints and Fittings, Copper Tube

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75M ASTM B 75. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.26.5 Valves

Valves shall be Class 125 and shall be suitable for the intended application. Valves shall meet the material, fabrication and operating requirements of ASME B31.1. Chain operators shall be provided for valves located 3 m 10 feet or higher above the floor.

2.26.5.1 Gate Valves

Gate valves 65 mm (2-1/2 inches) 2-1/2 inch and smaller shall conform to MSS SP-80 and shall be bronze with rising stem and threaded, soldered, or flanged ends. Gate valves 80 mm (3 inches) 3 inches and larger shall conform to MSS SP-70, Type I, II, Class 125, Design OF and shall be cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.26.5.2 Globe and Angle Valves

Globe valves 65 mm (2-1/2 inches) 2-1/2 inch and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Globe valves 80 mm (3 inches) 3 inches and larger shall conform to MSS SP-85 and shall be cast iron with bronze trim and flanged or threaded ends.

2.26.5.3 Check Valves

Check valves 65 mm (2-1/2 inches) 2-1/2 inch and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Check valves 80 mm (3 inches) 3 inches and larger shall conform to MSS SP-71, Type I, II, III, or IV, Class 125 or 150 and shall be cast iron with bronze trim and flanged or threaded ends.

2.26.5.4 Plug Valves

Tapered type valves, with a positive pressure sealant system providing for direct application of unseating pressure to the smaller end of the plug in all operating positions shall be used. Sealant grooves shall be arranged so as to completely surround the ports with the plug in the closed position and to prevent bypassing of sealant pressure to the line fluid passages in any position of the plug.

2.26.5.5 Ball Valves

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NOTE: Ball valves should be used only for drain valves or in makeup waterlines.

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Ball valves 15 mm (1/2 inch) 1/2 inch and larger shall conform to MSS SP-72 or MSS SP-110 and shall be ductile iron or bronze with threaded, soldered, or flanged ends.

2.26.5.6 Butterfly Valves

Butterfly valves shall be in accordance with MSS SP-67, Type 1 and shall be 2 flange or lug wafer type, and shall be bubble tight at 1000 kPa (150 psi). 150 psi. Valve bodies shall be cast iron, malleable iron, or steel. Valves smaller than 200 mm (8 inches) 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 200 mm (8 inches) 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

2.26.5.7 Manual Balancing Valves

Manual balancing valves, plug or ball type, shall conform to MSS SP-78. Valves 50 mm (2 inches) 2 inches or smaller shall be bonze with NPT connections for black steel pipe and brazed connections for copper tubing. Valves 25 mm (1 inch) 1 inch or larger shall be iron with threaded or flanged ends. Valves shall have a square head or similar device, an indicator arc, and be designed for 121 degrees C (250 degrees F). 250 degrees F. Iron valves shall be lubricated, nonlubricated, or tetrafluoroethylene resin-coated plug or ball valves. Manual balancing valves 200 mm (8 inches) 8 inches or larger shall be provided with manual gear operators with position indicators.

2.26.5.8 Calibrated Balancing Valves

Calibrated balancing valves shall have an integral pointer which registers the degree of valve opening or a lockable memory stop. Valves shall be calibrated so that flow can be determined when valve opening in degrees and pressure differential across the valve is known. Each balancing valve shall be constructed with internal seals to prevent leakage and be supplied with preformed insulation. Valves shall be suitable for 121 degrees C (250 degrees F) 250 degrees F temperature and for 862 kPa (125 psi) 125 psi or 150 percent of the system operating pressure, whichever is greater. Where flow readings are provided by remote or portable meters, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of the pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the valve. One portable flow meter, suitable for the operating pressure specified, shall be provided complete with hoses, vent, shutoff valves, and carrying case as recommended by the valve manufacturer.

2.26.5.9 Automatic Flow Control Valves

Automatic flow control valves shall maintain flow within 5 percent of the indicated flow rate when the inlet pressure is within the design range. A permanent nameplate or tags shall be attached to the valve that indicates

the factory-determined flow rate and corresponding inlet pressure levels. the valves shall be suitable for 862 kPa (125 psi) 125 psi or 150 percent of the system operating pressure, whichever is greater. The design pressure differential for each valve shall be [14] [25] [_____] kPa ([2] [5] [_____] psi). [2] [5] [_____] psi. Where flow readings are provided by remote or portable meters, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of the pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the valve. Automatic flow control valves may be substituted for venturi tubes or orifice plate flow measuring devices. One portable flow meter, suitable for the operating pressure specified, shall be provided complete with hosed, vent, shutoff valves, and carrying case as recommended by the valve manufacturer.

2.26.6 Accessories

2.26.6.1 Air Vents

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NOTE: Indicate the location of each air vent.
Distinguish between manual and automatic air vents.
****

Manual air vents shall be brass or bronze valves or cocks suitable for 862 kPa (125 psi) 125 psi service, and furnished with threaded plugs or caps. Automatic air vents shall be float type, cast iron, stainless steel, or forged steel construction, suitable for 862 kPa (125 psi) 125 psi service.

2.26.6.2 Strainers

Basket and "Y" type strainers shall be the same size as the pipelines in which they are installed. The strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. Strainers shall be designed for [_____] kPa ([_____] psi) [_____] psi and [_____] degrees C ([_____] degrees F) [_____] degrees F operating conditions. The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with removable cover and sediment screen. The screen shall be made of 0.8 mm (22 gauge) 22 gauge [brass sheet,] [monel,] [corrosion-resistant steel,] with small perforations numbering not less than 620,000 per square meter (400 per square inch) 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.26.6.3 Combination Strainer and Suction Diffuser

A combination strainer and suction diffuser, consisting of an angle type body with removable strainer basket and straightening vanes, a suction pipe support, and a blowdown outlet, shall be provided on pump suction. The combination strainer and suction diffuser shall be designed for [_____] kPa ([_____] psi) [_____] psi and [_____] degrees C ([_____] degrees F) [_____] degrees F operating conditions.

2.26.6.4 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 862 kPa (125 psi) 125 psi or 1034 kPa (150 psi) 150 psi service as appropriate for the static head plus the system head, and 121 degrees C (250 degrees F), 250 degrees F, 110 degrees C (230 degrees F) 230 degrees F for grooved end flexible connectors. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. The flexible section shall be suitable for intended service with end connections to match adjacent piping. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.26.6.5 Pipe Nipples

Pipe nipples shall be in accordance with ASTM A 733 and be of material to match adjacent piping.

2.26.6.6 Pipe Unions

Pipe unions shall be in accordance with ASME B16.39 and be of material to match adjacent piping.

2.26.6.7 Solder

Solder for water piping shall be in accordance with ASTM B 32, alloy grade 50B. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B 813.

2.26.7 Expansion Joints

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NOTE: Expansion loops, offsets, and bends will be used where possible instead of expansion joints and be located in serviceable areas. Expansion joints may only be installed on water piping.

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2.26.7.1 Slip-Tube Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the traverse indicated. The joints shall be designed for working temperature and pressure suitable for the application, but not less than 1034 kPa (150 psi), 150 psi, and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. End connections shall be flanged or beveled for welding as indicated. Joints shall be provided with an anchor base where required or indicated. Where adjoining pipe is carbon steel, the sliding slip shall be seamless steel plated with a minimum of 0.127 (5 mils) 5 mils of hard chrome in accordance with ASTM B 650. Joint components shall be

suitable for the intended service. Initial settings shall be made in accordance with the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer. Pipe alignment guides shall in no case be more than 1.5 m 5 feet from expansion joints except for pipe 100 mm (4 inches) 4 inches or smaller. Pipe alignment guides on pipe 100 mm (4 inches) 4 inches or smaller shall be installed not more than 600 mm 2 feet from expansion joints. Service outlets shall be provided where indicated.

2.26.7.2 Flexible Ball Joints

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NOTE: The ball joint only moves in an angular offset or rotation mode. The configuration of the ball joint link will require a 2 or 3 ball joint offset to absorb axial and/or lateral movement.

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Flexible ball joints shall be constructed of alloys as appropriate for the service intended. Where so indicated, the ball joint shall be designed for packing injection under full line pressure to contain leakage. The joint ends shall be threaded [to 50 mm (2 inches) 2 inches only], grooved, flanged, or beveled for welding as indicated or required and shall be capable of absorbing a minimum of 15 degree angular flex and 360 degree rotation. Ball and sockets shall be suitable for the intended service. The exterior spherical surface of carbon steel balls shall be plated with 0.127 mm (5 mils) 5 mils of hard chrome in accordance with EJMA Stds and ASME B31.1 where applicable. Where required, flanges shall conform to ASME B16.5.

2.26.7.3 Bellows Type Joints

Bellows type joints shall be flexible, guided expansion joints. The expansion element shall be stabilized corrosion resistant steel. Bellows type expansion joints shall conform to the applicable requirements of EJMA Stds and ASME B31.1 with internal sleeves. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but not less than 1034 kPa (150 psi). 150 psi.

2.27 REFRIGERANT PIPING

Refrigerant piping, valves, fittings, and accessories shall conform to the requirements of ASHRAE 15 and ASME B31.5, except as specified.

2.27.1 Steel Pipe

Steel pipe for refrigerant service shall conform to ASTM A 53, Schedule 40, Type E or S, Grades A or B. Type F pipe shall not be used.

2.27.2 Joints and Fittings, Steel Pipe

Joints and fittings shall be steel butt-welding, socket-welding, or malleable iron threaded type. Pipe shall be welded except that joints on lines 50 mm (2 inches) 2 inches and smaller may be threaded. Threads shall be tapered type conforming to ASME B1.20.1. The malleable iron threaded type fitting shall be of a weight corresponding to adjacent pipe. Flanges and flange faces of fittings shall be tongue-and-groove type with gaskets suitable for the refrigerant used; size 25 mm (1 inch) 1 inch and smaller shall be oval, two-bolt type; size above 25 mm (1 inch), 1 inch, up to and including 100 mm (4 inches), 4 inches, shall be square four-bolt type; and sizes over 100 mm (4 inches) 4 inches shall be round.

2.27.3 Steel Tubing

Steel tubing for refrigeration service shall be in accordance with ASTM A 334/A 334M, Grade 1. Tubing with a nominal diameter of 10 mm (3/8 inch) 3/8 inch or 15 mm (1/2 inch) 1/2 inch shall have a wall thickness of 1.22 mm (0.049 inches). 0.049 inches. Tubing with a nominal diameter of 20 mm (3/4 inch) 3/4 inch through 50 mm (2 inches) 2 inches shall have a wall thickness of 1.62 mm (0.065 inches). 0.065 inches. Tubing with a nominal diameter of 65 through 100 mm (2 1/2 inches through 4 inches) 2 1/2 inches through 4 inches shall have a wall thickness of 2.4 mm (0.095 inches). 0.095 inches. Steel tubing shall be cold-rolled, electric-forged, welded-steel. One end of the tubing shall be provided with a socket. Steel tubing shall be cleaned, dehydrated, and capped.

2.27.4 Joints and Fittings, Steel Tubing

Joints and fittings shall be socket type provided by the steel tubing manufacturer.

2.27.5 Copper Tubing

Copper tubing shall conform to ASTM B 280 annealed or hard drawn as required. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 35 mm (1-3/8 inches). 1-3/8 inches. Joints shall be brazed except that joints on lines 22 mm (7/8 inch) 7/8 inch and smaller may be flared.

2.27.6 Joints and Fittings, Copper Tubing

Copper tube joints and fittings shall be flare joint type with short-shank flare, or solder-joint pressure type. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings shall not be allowed for brazed joints.

2.27.7 Valves

Valves shall be pressure and temperature rated for contained refrigerant service and shall comply with ASME B31.5. Metals of construction shall be ferrous or copper based. Atmosphere exposed valve stems shall be stainless steel or corrosion resistant metal plated carbon steel. Valve body connections shall be brazed or welded socket, flanged or combination thereof. Threaded connections shall not be used, except in pilot pressure

or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Valves shall be suitable for or fitted with extended copper ends for brazing in-place without disassembly. Ferrous body valves shall be fitted with factory fabricated and brazed copper transitions. To minimize system pressure drops, where practicable, globe valves shall be angle body type, and straight line valves shall be full port ball type. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by manufacturer. Valves shall be cleaned and sealed moisture-tight.

2.27.7.1 Refrigerant-Stop Valves

Valves, in sizes through 15 mm (5/8 inch), 5/8 inch, shall be handwheel operated, straight or angle, packless diaphragm globe type with back-seating stem, brazed ends, except where SAE flare or retained seal cap connections are required. In sizes over 15 mm (5/8 inch), 5/8 inch, valves shall be globe or angle type, wrench operated with ground-finish stems, or ball valves, packed especially for refrigerant service, back seated, and provided with seal caps. Refrigerant isolation and shut-off valves shall have retained or captive spindles and facilities for tightening or replacement of the gland packing under line pressure as applicable. Stop valves shall have back-seating plated steel stem, bolted bonnet in sizes 25 mm (1-1/8 inches) 1-1/8 inches OD and larger, integral or flanged transition brazed socket. Valves in sizes through 65 mm (2-1/2 inches) 2-1/2 inches shall be end-entry body assembly, full-port, floating ball type, with equalizing orifice fitted chrome plated ball, seats and seals of tetrafluoroethylene, chrome plated or stainless steel stem, and seal cap. In sizes 100 mm (4 inch) 4 inch IPS and larger, and in smaller sizes where carbon steel piping is used, valve bodies shall be tongue and groove flanged and complete with mating flange, gaskets and bolting for socket or butt-weld connection. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

2.27.7.2 Check Valves

Valve shall be designed for service application, spring-loaded type where required, with resilient seat and with flanged body in sizes 15 mm (1/2 inch) 1/2 inch and larger. Valve shall provide positive shut-off at [10] [14] [20] kPa ([1-1/2] [2] [3] psi) [1-1/2] [2] [3] psi differential pressure.

2.27.7.3 Liquid Solenoid Valves

Valves shall comply with ARI 760 and be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 2760 kPa (400 psi) 400 psi and a maximum operating pressure differential of at least 1375 kPa (200 psi) 200 psi at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

2.27.7.4 Expansion Valves

Expansion valves conform to requirements of ARI 750. Valve shall be of the diaphragm and spring type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 1 degrees C (2 degrees F) 2 degrees F of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicated or for constant evaporator loads.

2.27.7.5 Safety Relief Valve

Valve shall be the two-way type. Single type valves shall be used only where indicated. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

2.27.7.6 Evaporator Pressure Regulators, Direct-Acting

Valve shall include a diaphragm/spring power assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1 degrees C 2 degrees F change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

2.27.7.7 Refrigerant Access Valves

Refrigerant access valves and hose connections shall be in accordance with ARI 720.

2.27.8 Accessories

2.27.8.1 Filter Driers

Driers shall conform to ARI 710. Sizes 15 mm (5/8 inch) 5/8 inch and larger shall be the full flow, replaceable core type. Sizes 12 mm (1/2

inch) 1/2 inch and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10.3 MPa (1,500 psi). 1,500 psi.

2.27.8.2 Sight Glass and Liquid Level Indicator

a. Assembly and Components: Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.

b. Gauge Glass: Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

c. Bull's-Eye and Inline Sight Glass Reflex Lens: Bull's-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlighted viewing shall be provided.

d. Moisture Indicator: Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each corresponding sight glass.

2.27.8.3 Vibration Dampeners

Dampeners shall be of the all-metallic bellows and woven-wire type.

2.27.8.4 Flexible Pipe Connectors

Connector shall be pressure and temperature rated for the service in accordance with ASHRAE 15 and ASME B31.5. Connector shall be a composite of interior corrugated phosphor bronze or Type 300 Series Stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 150 degrees C (300 degrees F). 300 degrees F. Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

2.27.8.5 Strainers

Strainers used in refrigerant service shall have brass or cast iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.27.8.6 Brazing Materials

Brazing materials for refrigerant piping shall be in accordance with AWS A5.8, Classification BCuP-5.

2.28 DRAIN AND MISCELLANEOUS PIPING

Piping, fittings, valves and accessories for drain and miscellaneous services shall be in accordance with Section 15400 PLUMBING, GENERAL PURPOSE.

2.29 FACTORY COATINGS

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NOTE: A salt fog test should be required for all outdoor equipment. Specify a 125-hour test in noncorrosive environments and a 500-hour test in a corrosive environments.

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Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand [125] [500] hours exposure to the salt spray test specified in ASTM B 117 using a 25 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of ASME BPV VIII Div 1 and ASME BPV IX, the design, fabrication, and installation of the system shall conform to ASME BPV VIII Div 1 and ASME BPV IX.

3.1.1 Equipment

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NOTE: Determine in the initial stages of design the approximate distances required for maintenance clearances of all new equipment. The maintenance clearances will be used in determining the final layout of the equipment. For installations where noise and vibration transmission to the building must be reduced, the maximum tolerable transmissibility, in percent, should be determined

and the blank filled in with appropriate value. When it is not necessary to specify the percent of transmissibility, the item in the brackets will be deleted and brackets removed. Recommended transmissibility in percentages are: 10 percent for equipment mounted in very critical areas; 10 to 20 percent for critical areas; and 20 to 40 percent for noncritical areas. The drawings should be checked to ensure that all structural and equipment connection factors and the conditions surrounding the equipment to be provided with the vibration isolation units favorably influence the effectiveness of the isolators. Where many items of equipment require different transmission values, based on the equipment location, the specification may be revised to indicate the appropriate values on the drawings.

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Refrigeration equipment and the installation thereof shall conform to ASHRAE 15. Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, and similar items. Compressors shall be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations shall be provided. Each foundation shall include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment shall be set on not less than a 150 mm 6 inch concrete pad doweled in place. Concrete foundations for floor mounted pumps shall have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block shall be of mass not less than three times the combined pump, motor, and base weights. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Lines connected to pumps mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.2 Mechanical Room Ventilation

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For mechanical rooms which are intended to house refrigeration equipment, designers will use ASHRAE 15 to determine applicable design criteria. Delete this paragraph if a mechanical room is not applicable to the design.

In summary, ASHRAE 15 allows the use of either natural or mechanical ventilation systems, however, natural ventilation is allowed only in certain limited applications. Natural ventilation is allowed only when "a refrigerant system is located outdoors more than 6.1 m (20 ft) from building openings and is enclosed by a penthouse, lean-to or other open structure", otherwise mechanical ventilation is required.

The amount of ventilation air required for a mechanical room will be determined based upon the ventilation equations in ASHRAE 15. In order to use these equations, a designer must approximate the mass of refrigerant (kgs or lbs) expected in the largest system located in the mechanical room.

Refrigerant quantities will be determined based upon a minimum of 2 different system manufacturers.

a. For a natural ventilation system, ASHRAE 15 provides an equation for sizing the amount of free opening area required.

b. For a mechanical ventilation system, ASHRAE 15 requires both normal and alarm ventilation. Normal ventilation will be sized to cover personnel ventilation requirements (2.5 1/s/m2 or 0.5 cfm/ft2) and heat buildup requirements if applicable. Alarm ventilation will be sized based upon the equations in ASHRAE 15. Both the normal and alarm ventilation rates can be achieved using the same ventilation system (e.g., multi-speed exhaust fans), however, individual systems are preferred. For the alarm ventilation, exhaust intakes will be located near the equipment and close to the finished floor. Most commonly used refrigerants are heavier-than-air and subsequently sink to the floor. Also per ASHRAE 15, air supply and exhaust ducts to the mechanical room will serve no other area within a facility. Discharge air from a mechanical ventilation system will be to the outdoors.

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Mechanical ventilation systems shall be in accordance with Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM.

3.1.3 Building Surface Penetrations

Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A 653/A 653M, Coating Class G-90, 1.0 mm (20 gauge).20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A 53, [Schedule 30] [Schedule 20] [Standard weight]. Sealants shall be applied to moisture and oil-free surfaces and

elastomers to not less than 13 mm 1/2 inch depth. Sleeves shall not be installed in structural members.

3.1.3.1 Refrigerated Space

Refrigerated space building surface penetrations shall be fitted with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Sleeves shall be constructed with integral collar or cold side shall be fitted with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, voids shall be filled with latex mixed mortar cast to shape of sleeve and flange/external collar type sleeve shall be assembled with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Integral cast-in collar type sleeve shall be flashed [as indicated.] [with not less than 100 mm (4 inches) 4 inches of cold side vapor barrier overlap of sleeve surface.] Normally noninsulated penetrating round surfaces shall be sealed to sleeve bore with mechanically expandable seals in vapor tight manner and remaining warm and cold side sleeve depth shall be insulated with not less than [100] [_____] mm ([4] [_____] inches) [4] [_____] inches of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Vapor barrier sealant shall be applied to finish warm side insulation surface. Warm side of penetrating surface shall be insulated beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Wires in refrigerated space surface penetrating conduit shall be sealed with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.1.3.2 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of 6.35 mm 1/4 inch all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07900 JOINT SEALING.

3.1.3.3 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 17-ounce copper sleeve, or a 0.81 mm (0.032 inch) 0.032 inch thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm 8 inches from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm 2 inches above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 250 mm 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.3.4 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07840 FIRESTOPPING.

3.1.3.5 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.4 Access Panels

Access panels shall be provided for all concealed valves vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500 MISCELLANEOUS METALS.

3.1.5 General Piping Installation

3.1.5.1 Brazed Joints

Brazing shall be performed in accordance with AWS Brazing Hdbk, except as modified herein. During brazing, the pipe and fittings shall be filled

with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Joints in steel tubing shall be painted with the same material as the baked-on coating within 8 hours after joints are made. Tubing shall be protected against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.5.2 Threaded Joints

Threaded joints shall be made with tapered threads and made tight with PTFE tape complying with ASTM D 3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.5.3 Welded Joints

Welded joints in steel refrigerant piping shall be fusion-welded. Changes in direction of piping shall be made with welded fittings only; mitering or notching pipe or other similar construction to form elbows or tees will not be permitted. Branch connections shall be made with welding tees or forged welding branch outlets. Steel pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with AWS D1.1 or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.5.4 Flanged Joints

Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for use with the refrigerants to be handled. When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, refrigeration equipment, control valves, and other similar items.

3.1.5.5 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.6 Condenser Water Piping

Pipe and fitting installation shall conform to the requirements of ASME

B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.1.6.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) 4 inches and smaller will be permitted, provided a pipe bender is used and wide weep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.1.6.2 Functional Requirements

Horizontal supply mains shall pitch down in the direction of flow as indicated. The grade shall not be less than 2 mm per meter. 1 inch in 40 feet. Reducing fittings shall be used for changes in pipe sizes. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of the system. Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 65 mm (2-1/2 inches) 2-1/2 inches or less in diameter, and with flanges for pipe 75 mm (3 inches) 3 inches or more in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric unions or flanges. Piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded.

3.1.6.3 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.6.4 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.6.5 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps [or plugged tees] unless otherwise indicated.

3.1.6.6 Flexible Pipe Connectors

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NOTE: Flexible pipe connectors will be provided where required to absorb expansion and contraction, isolate vibration, absorb noise, compensate offset motion, absorb continuous flexing, and relieve equipment from piping stresses. Where flexible pipe connectors are needed to correct lateral, parallel, and angular misalignment, their use will be limited to maximum offset as recommended, in writing, by the manufacturer. Flexible pipe connectors will only be used on water piping.

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Preinsulated flexible pipe connectors shall be attached to other components in strict accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.6.7 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items.

3.1.6.8 Grooved Mechanical Joints

Grooves shall be prepared in accordance with the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, or narrow-land micrometer. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances.

3.1.7 Refrigeration Piping

Unless otherwise specified, pipe and fittings installation shall conform to requirements of ASME B31.5. Pipe shall be cut accurately to measurement established at the jobsite and worked into place without springing or forcing. Cutting or otherwise weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipes shall be cut square, shall have burrs removed by reaming, and shall be installed in a manner to permit free expansion and contraction without damage to joints or hangers. Filings, dust, or dirt shall be wiped from interior of pipe before connections are made.

3.1.7.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of

pipe 100 mm (4 inches) 4 inches and smaller will be permitted, provided a pipe bender is used and wide-sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, or other malformations will not be accepted.

3.1.7.2 Functional Requirements

Piping shall be installed 4 mm per meter 1/2 inch per 10 feet of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings.

3.1.7.3 Manual Valves

Stop valves shall be installed on each side of each piece of equipment such as compressors, condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Angle and globe valves shall be installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm. 1 inch. Filter dryers having access ports may be considered a point of isolation. Purge valves shall be provided at all points of systems where accumulated noncondensible gases would prevent proper system operation. Valves shall be furnished to match line size, unless otherwise indicated or approved.

3.1.7.4 Expansion Valves

Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 54 mm (2-1/8 inches) 2-1/8 inches in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 54 mm (2-1/8 inches). 2-1/8 inches. The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing shall be facing up.

3.1.7.5 Valve Identification

Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 34 mm (1-3/8 inch) 1-3/8 inch diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 14 gauge 14 gauge annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

3.1.7.6 Vibration Dampers

Vibration damper shall be provided in the suction and discharge lines on spring mounted compressors. Vibration dampers shall be installed parallel with the shaft of the compressor and be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.1.7.7 Strainers

Strainers shall be provided immediately ahead of solenoid valves and expansion devices and where indicated. Strainers may be an integral part of the expansion valve.

3.1.7.8 Filter Dryer

A liquid line filter dryer shall be provided on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. Dryers shall be sized in accordance with the manufacturers recommendations. A dryer shall be installed such that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.1.7.9 Sight Glass

A moisture indicating sight glass shall be installed in all refrigerant circuits down stream of filter dryers and where indicated. Sight glass shall be full line size.

3.1.7.10 Flexible Connectors

Flexible metallic connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required.

3.1.8 Thermometers

Thermometers located within 1.5 m 5 feet of floor may be rigid stem type. Where thermal well is located above 1.5 m 5 feet above floor, thermometer shall be universal adjustable angle type or remote element type to 2.1 m 7 feet above floor and remote element type where thermal well is 2.1 m 7 feet or more above floor. Thermometers shall be located in coolant supply and return or waste lines at each heat exchanger, condenser water lines entering and leaving the condenser, at each automatic temperature control device without an integral thermometer, refrigerant liquid line leaving receiver, refrigerant suction line at each evaporator or liquid cooler, and where indicated or required for proper operation of equipment.

3.1.9 Piping Supports

Refrigerant pipe supports shall be in accordance with ASME B31.5. Hangers used to support piping 50 mm (2 inches) 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.9.1 Seismic Requirements

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NOTE: Provide seismic requirements, if a Government designer (either Corps office or A/E) is the Engineer of Record and show on drawings. Delete the bracketed phrase if no seismic requirements are provided. Sections 13080 and 15070, properly edited, must be included in the contract documents.

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Piping and attached valves shall be supported and braced to resist seismic loads as specified under Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT [as indicated]. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section. Material used for support shall be as specified under Section 05210 STRUCTURAL STEEL.

3.1.9.2 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Material used for support shall be as specified under Section 05210 STRUCTURAL STEEL.

3.1.10 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used.

3.1.10.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.10.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if

they otherwise meet the requirements for Type 18 inserts.

3.1.10.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.10.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.10.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) 4 inches and larger when the temperature of the medium is 16 degrees C 60 degrees F or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) 4 inches and all piping 100 mm (4 inches) 4 inches and larger carrying medium less than 16 degrees C. 60 degrees F. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) 2 inches and larger.

3.1.10.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m 5 feet apart at valves. [Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 222 N (50 pounds) 50 pounds shall have the excess hanger loads suspended from panel points.]

3.1.10.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m, 15 feet, not more than 2.4 m 8 feet from end of risers, and at vent terminations.

3.1.10.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.10.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) 4 inches and larger, a Type 39 saddle shall be used. On piping

under 100 mm (4 inches), 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.10.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm, 4 inches, or by an amount adequate for the insulation, whichever is greater.

3.1.10.11 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.11 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1.5 m 5 feet on each side of each expansion joint, and in lines 100 mm (4 inches) 4 inches or smaller not more than 2 feet on each side of the joint.

3.1.12 Pipe Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.1.13 Pipe Color Code Marking

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NOTE: Designer will coordinate color code marking with Section 09900. Color code marking for piping not listed in Table 1 of Section 09900 will be added to the table.

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Color code marking of piping shall be as specified in Section 09900 PAINTING, GENERAL.

3.1.14 Metal Ductwork

Installation shall be in accordance with SMACNA TAB HVAC Sys unless otherwise indicated. Duct supports for sheet metal ductwork shall be in accordance with SMACNA TAB HVAC Sys, unless otherwise specified. Friction beam clamps indicated in SMACNA TAB HVAC Sys will not be used. [Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion.] Supports on the risers shall allow free vertical movement of the duct. Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided.

3.1.15 Fibrous Glass Ductwork

Installation shall be in accordance with the manufacturer's written recommendations unless otherwise required in NAIMA AH115. Duct supports for fibrous glass ductwork shall conform to NAIMA AH115. In those cases not covered in NAIMA AH115, the written recommendation of the fibrous duct manufacturer shall be followed.

3.1.16 Acoustical Duct Lining

Lining shall be applied in cut-to-size pieces attached to the interior of the duct with nonflammable, fire-resistant adhesive conforming to ASTM C 916, Type I, NFPA 90A, UL 723, and ASTM E 84. Top and bottom pieces shall lap the side pieces and shall be secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed in accordance with SMACNA TAB HVAC Sys. Welded pins, cup-head pins, or adhered clips shall not distort the duct, burn through, nor mar the finish or the surface of the duct. Pins and washers shall be flush with the surfaces of the duct liner and all breaks and punctures of the duct liner coating shall be sealed with the nonflammable, fire-resistant adhesive. Exposed edges of the liner at the duct ends and at other joints where the lining will be subject to erosion shall be coated with a heavy brush coat of the nonflammable, fire-resistant adhesive to prevent delamination of glass fibers. Duct liner may be applied to flat sheet metal prior to forming duct through the sheet metal brake. Lining at the top and bottom surfaces of the duct shall be additionally secured by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA TAB HVAC Sys to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, will be acceptable.

3.1.17 Field Applied Insulation

Field applied insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.18 Factory Applied Insulation

[Refrigerant suction lines between an evaporator and compressors [and any

cold gas inlet connections to gas cooled motors]] [Refrigerant pumps and exposed chilled water lines] shall be insulated with not less than 19 mm (3/4 inch) 3/4 inch thick unicellular plastic foam.

3.1.19 Framed Instructions

Framed instructions shall be framed under glass or laminated plastic and be posted where directed. Instructions shall include equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The instructions shall be posted before acceptance testing of the system.

3.2 TESTS

Tests shall be conducted in the presence of the Contracting Officer. Utilities for testing shall be provided as specified in the SPECIAL CONTRACT REQUIREMENTS. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. The services of a qualified technician shall be provided as required to perform all tests and procedures indicated herein. Field tests shall be coordinated with Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.2.1 Condenser Water System

After cleaning, water piping shall be hydrostatically tested at a pressure equal to 150 percent of the total system operating pressure for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Leaks shall be repaired and piping retested until test is successful. No loss of pressure shall be allowed. Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before concealing.

3.2.2 Refrigerant System

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NOTE: The following refrigerant system tests are for field fabricated refrigerant piping systems. The tests do not apply to packaged, unitary systems which are charged at the factory.
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After all components of the refrigerant system have been installed and connected, the entire refrigeration system shall be subjected to a pneumatic test as described herein.

3.2.2.1 Preliminary Procedures

Prior to pneumatic testing, equipment which has been factory tested and

refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

3.2.2.2 Pneumatic Test

Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus 55 degrees C (minus 70 degree F) minus 70 degree F dewpoint and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 69 kPa (10 psi) 10 psi with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ASHRAE 15 with a maximum test pressure 25 percent greater. Pressure above 690 KPa (100 psig) 100 psig shall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of the 24 hour period, the system pressure will be recorded along with the ambient temperature to which the system is exposed. A correction factor of 2 kPa (0.3 psi) 0.3 psi will be allowed for each degree C (F) F change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, then the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing shall not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

3.2.2.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 300 micrometers. During evacuation of the system, the ambient temperature shall be higher than 2 degrees C. 35 degrees F. No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 500 micrometers after the 1 hour period, then the system shall be evacuated again down to 300 micrometers and let set for another 1 hour period. The system shall not be charged until a vacuum of at least 500 micrometers is maintained for a period of 1 hour without the assistance of a vacuum line. If during the testing the pressure continues to rise, check the system for leaks, repair as required, and repeat the evacuation procedure. During evacuation, pressures shall be recorded by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

3.2.2.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors.

3.2.2.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances shall the refrigerant be discharged into the atmosphere.

3.2.2.6 Contractor's Responsibility

The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time shall more than 85 g (3 ounces) 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.2.3 Ductwork Leak Tests

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NOTE: This paragraph may be omitted where all ductwork is constructed to static pressure Class 125, 250, 500 Pa (1/2, 1 or 2 inch W.G.). Otherwise, leakage rate will be derived for each system to be tested based on procedure outlined in SMACNA Leakage Test Mnl for Seal Class A. If round/oval metal ductwork only is specified C sub L = 3 will be used, otherwise C sub L = 6 may be used. The value of P used will be equal to the highest duct static pressure class; i.e., 750, 1000, 1500, or 2500 Pa (3, 4, 6, or 10), for the ductwork to be tested. Where major components such as fans, coils, filters, etc., will be included in ductwork test, an appropriate allowance will be included in the maximum allowable leakage rate.

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Ductwork leak test shall be performed for the entire air distribution system, including fans, coils, filters, etc., [designated as static pressure Class 750 Pa (3 inch water gauge) 3 inch water gauge through Class

2500 Pa (10 inch water gauge). 10 inch water gauge.] Test procedure, apparatus, and report shall conform to SMACNA Leakage Test Mnl. The maximum allowable leakage rate is [_____] L/s ([_____] CFM). [_____] CFM. Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

3.2.4 Cooling Tower Tests

After cooling tower have been found acceptable under the visual and dimensional examination, a field performance test shall be performed in accordance with ASME PTC 23 or CTI ATC-105. [The [electromagnetic interference suppression test and the] [salt spray test is not required].] The cooling tower test shall be performed in the presence of a Government representative.

3.2.5 Condenser Water Quality Tests

The condenser water shall be analyzed a minimum of once a month for a period of one year by the water treatment company. The analysis shall include the following information recorded in accordance with ASTM D 596.

Date of Sample	[_____]	
Temperature	[_____]	degrees C F
Silica (SiO2)	[_____]	ppm (mg/1)
Insoluble	[_____]	ppm (mg/1)
Iron and Aluminum Oxides	[_____]	ppm (mg/1)
Calcium (Ca)	[_____]	ppm (mg/1)
Magnesium (Mg)	[_____]	ppm (mg/1)
Sodium and Potassium (Na and K)	[_____]	ppm (mg/1)
Carbonate (HCO3)	[_____]	ppm (mg/1)
Sulfate (SO4)	[_____]	ppm (mg/1)
Chloride (Cl)	[_____]	ppm (mg/1)
Nitrate (NO3)	[_____]	ppm (mg/1)
Turbidity	[_____]	unit
pH	[_____]	
Residual Chlorine	[_____]	ppm (mg/1)
Total Alkalinity	[_____]	epm (meq/1)
Non-Carbonate Hardness	[_____]	epm (meq/1)
Total Hardness	[_____]	epm (meq/1)
Dissolved Solids	[_____]	ppm (mg/1)
Fluorine	[_____]	ppm (mg/1)
Conductivity	[_____]	micrmho/cm

3.2.6 System Performance Tests

After the foregoing tests have been completed and before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than [48] [_____] hours for each system and demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be

made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested.

3.3 INSPECTIONS

At the conclusion of the one year period, cooling towers and condensers shall be inspected for problems due to corrosion, scale, and biological growth. If the cooling tower and condenser are found not to conform to the manufacturers recommended conditions, assuming the water treatment company recommendations have been followed; the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

3.4 CLEANING AND ADJUSTING

3.4.1 Piping

Prior to testing, pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from each water system through the use of the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented.

3.4.2 Ductwork

Prior to testing, inside of ducts, plenums, and casing shall be thoroughly cleaned of all debris and blown free of small particles of rubbish and dust and then vacuum cleaned before installing outlet faces. Temporary filters shall be provided for fans that are operated during construction. New filters shall be installed after all construction dirt has been removed from the building and the ducts, plenum, casings, and other items specified have been vacuum cleaned. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.4.3 Equipment

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. System shall be maintained in this clean condition until final acceptance. Bearings shall be lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.4.4 Testing, Adjusting, and Balancing

Testing, adjusting, and balancing shall be as specified in Section 15990

TESTING, ADJUSTING AND BALANCING OF HVAC SYSTEMS.

3.5 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations.

-- End of Section --